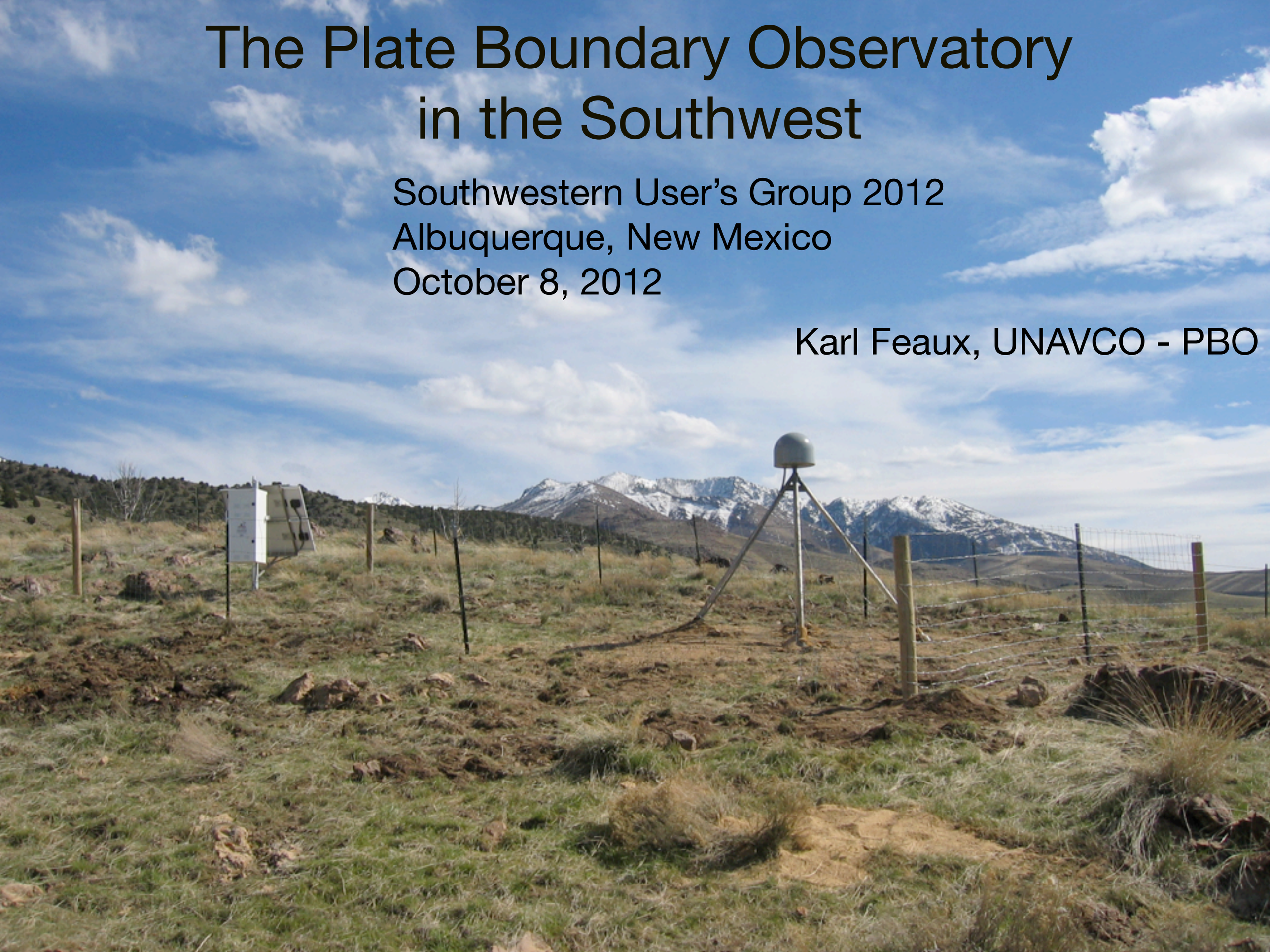
The Plate Boundary Observatory in the Southwest

Southwestern User's Group 2012
Albuquerque, New Mexico
October 8, 2012

Karl Feaux, UNAVCO - PBO



Talk Outline

1. UNAVCO, EarthScope and The Plate Boundary Observatory

2. PBO in the Southwest

3. Rio Grand Rift Project - GPS Stations in New Mexico and Colorado

UNAVCO Consortium

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

Currently there are 149 UNAVCO Members
(87 Full Members, 62 Associate Members)

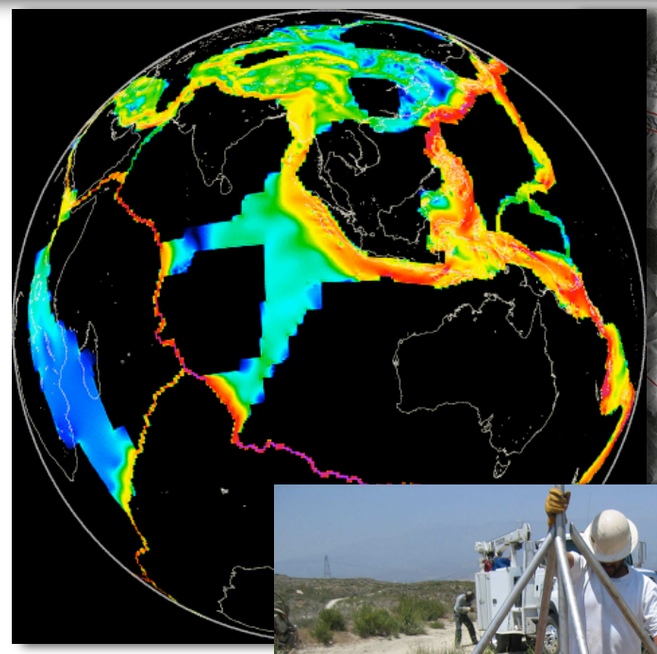
UNAVCO Member Institutions Listing and Map - Large

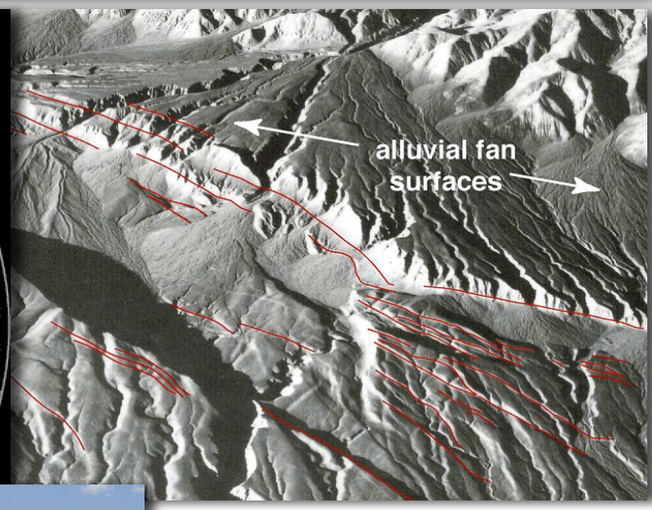
149 UNAVCO Members

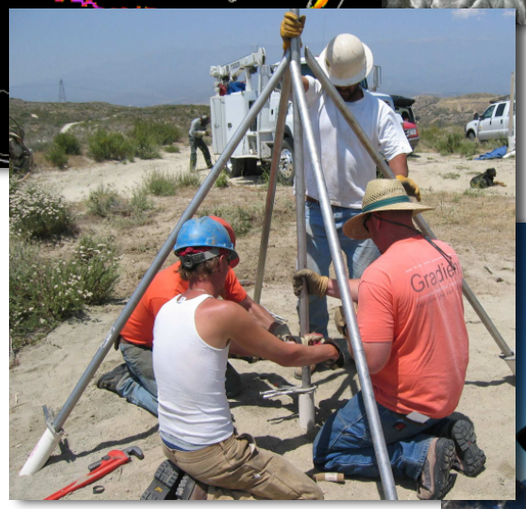
(F) = Founding Member

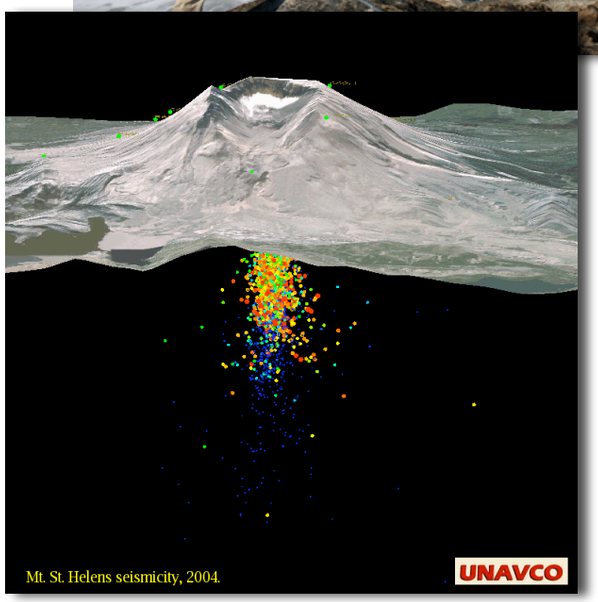
- Appalachian State University
- Baylor University
- Boise State University
- California Institute of Technology
- California State University, Fullerton
- California State University, Stanislaus
- Carnegie Institution of Washington
- Central Washington University
- Columbia University
- Cornell University
- Georgia Institute of Technology
- Grand Valley State University
- Hamilton College
- Harvard University
- Humboldt State University
- Idaho State University
- Indiana University
- Jet Propulsion Laboratory
- Los Alamos National Laboratory
- Louisiana State University
- Macalester College
- Massachusetts Institute of Technology
- Michigan Technological University
- Missouri State University
- New Mexico Institute of Mining and Technology
- New Mexico State University
- New York University
- North Carolina State University

UNAVCO Consortium









<u>UNAVCO Support</u>

- Engineering Services
    - Small and Large network Installation
    - O&M
    - Development and Testing
- Equipment Pool
- Data Management and Archiving
- CyberInfrastructure
- Education and Outreach

<u>Technologies - A Growing Geodetic “Toolbox”</u>

- GNSS (GPS, GLONASS, Galileo)
  with ancillary meteorological instruments
- Borehole Strainmeters and Seismometers and ancillary sensors
- Accelerometers
- Borehole Tiltmeters
- Geodetic Imaging
    - Terrestrial Laser Scanners
    - Airborne Laser Swath Mapping project support
    - InSAR Data Archives (WInSAR/EarthScope)

EarthScope

- Funded by NSF
- Project started in 2003 - continues through 2018
- Three Components - Geodetic, Seismic, and Drilling
- Deploys thousands of seismic, GPS, and other geophysical instruments
- Purpose: To study the structure and evolution of the North American continent and the processes the cause earthquakes and volcanic eruptions.
- A collaboration between scientists, educators, policy makers, and the public to learn about and utilize exciting scientific discoveries as they are being made.

#1 Most Epic Big Science Project

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Big Science: The Universe's Ten Most Epic Projects

By Gregory Mone, Brooke Borel, Katherine Bagley and Jennifer Abbasi Posted 7.16.11 at 8:06 pm 12 Comments

IMAGE 10 OF 10

1: The Earthscope

EarthScope

A telescope to peer deep into the heart of our planet

Designed to track North America's geological evolution, EarthScope is the largest science project on the planet. This earth-sciences observatory records data over 3.8 million square miles. Since 2003, its more than 4,000 instruments have amassed 67 terabytes of data—that's equivalent to more than a quarter of the data in the Library of Congress—and add another terabyte every six to eight weeks

Scientific Utility

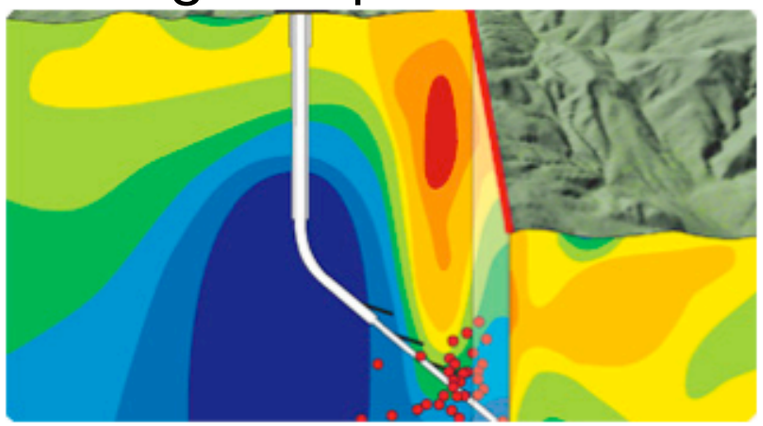
Researchers are using EarthScope, which consists of many kinds of experiments, to examine all facets of North America's geological composition. Across the continental U.S. and Puerto Rico, 1,100 permanent GPS units track deformations in the land's surface caused by tectonic shifts below. Seismic sensors next to the active San Andreas Fault in California record its tiniest slips, while rock samples pulled from a drill site that extends two miles into the fault 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 over 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, they will have collected data from almost 2,000 locations.

What's In It For You

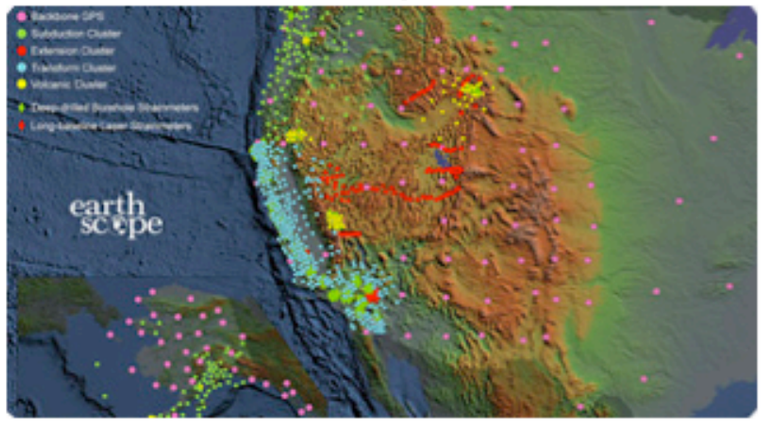
Collectively, EarthScope's measurements could help explain the forces behind geological events such as earthquakes and volcanic eruptions, leading to better detection. So far, data from the project has shown that rocks in the San Andreas Fault are weaker than those outside it and that the plume of magma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

Annual budget: $25,000,000
Construction cost: $197,000,000
Staff: 110
Physical size: 3.8 million square miles
Scientific utility: 10
WIIFY: 10
Wow factor: 10

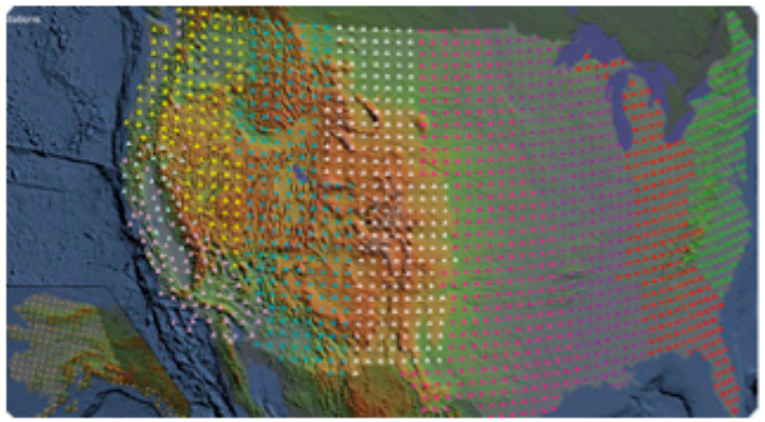
Drilling Component - SAFOD



Geodetic Component - PBO



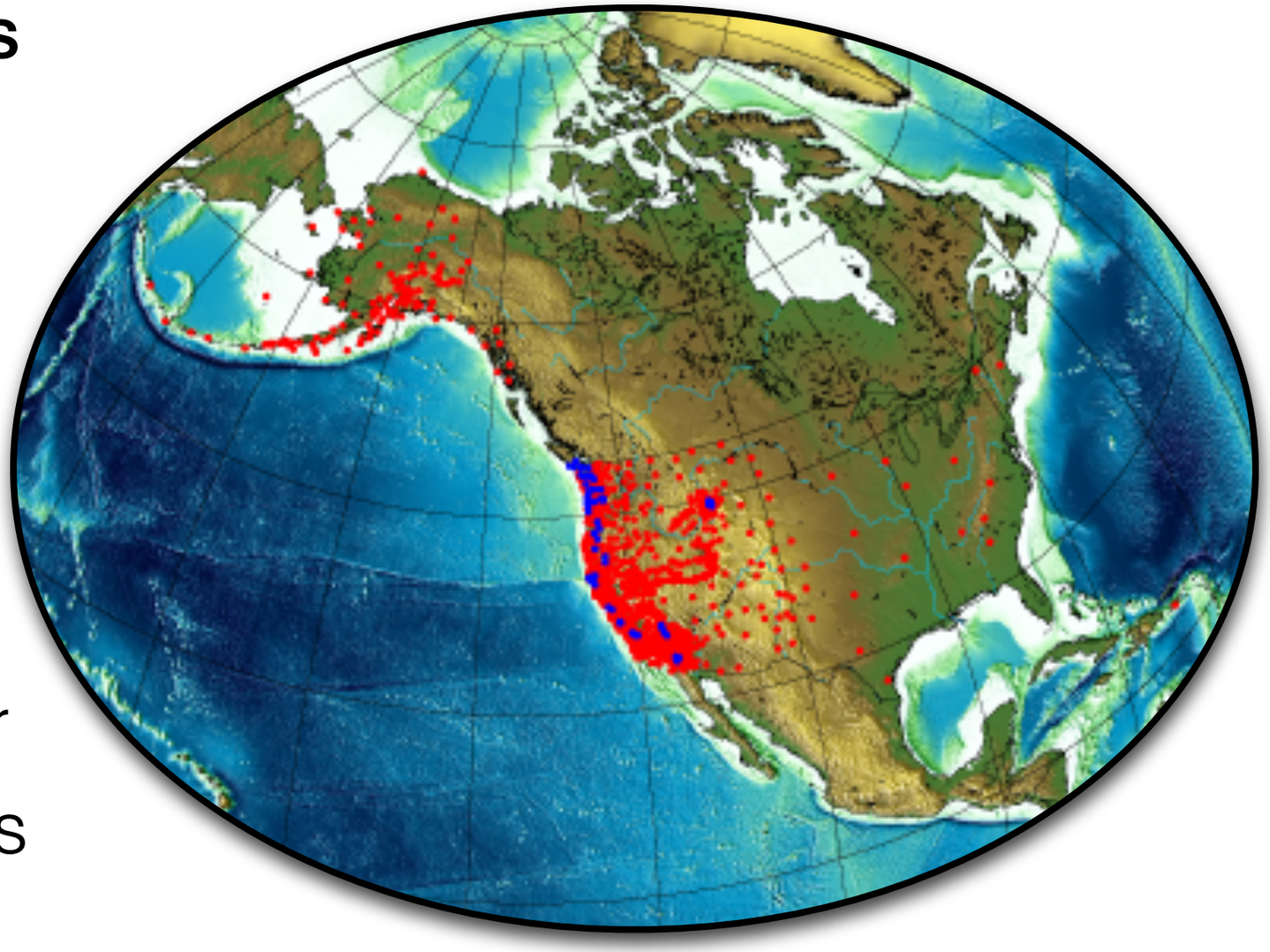
Seismic Component - USArray



The Plate Boundary Observatory

Focused, dense deployments of GPS and strainmeters

- 1100 continuous Global Positioning Systems around tectonic clusters
- 78 borehole strainmeters
- 5 long baseline strainmeters
- 26 tiltmeters
- 100 meteorological instruments

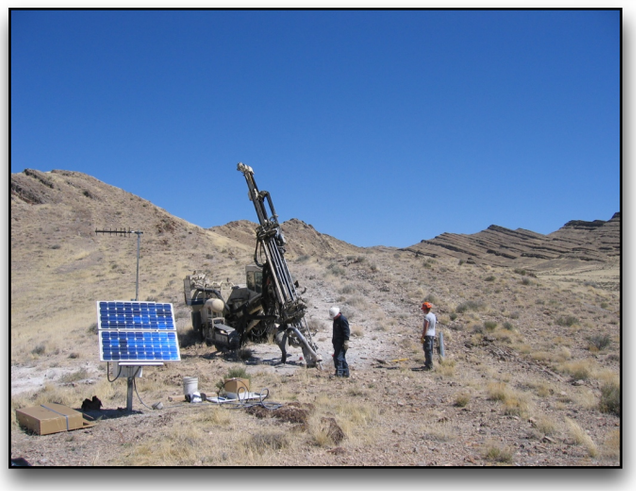


Portable GPS receivers

- Pool of 100 portable GPS receivers for temporary deployments to areas not sufficiently covered by continuous GPS

Geo-EarthScope

- InSAR imagery covering the western US
- LIDAR imagery covering the northern and southern San Andreas Fault, Yellowstone Caldera, and faults in Cascadia and Alaska

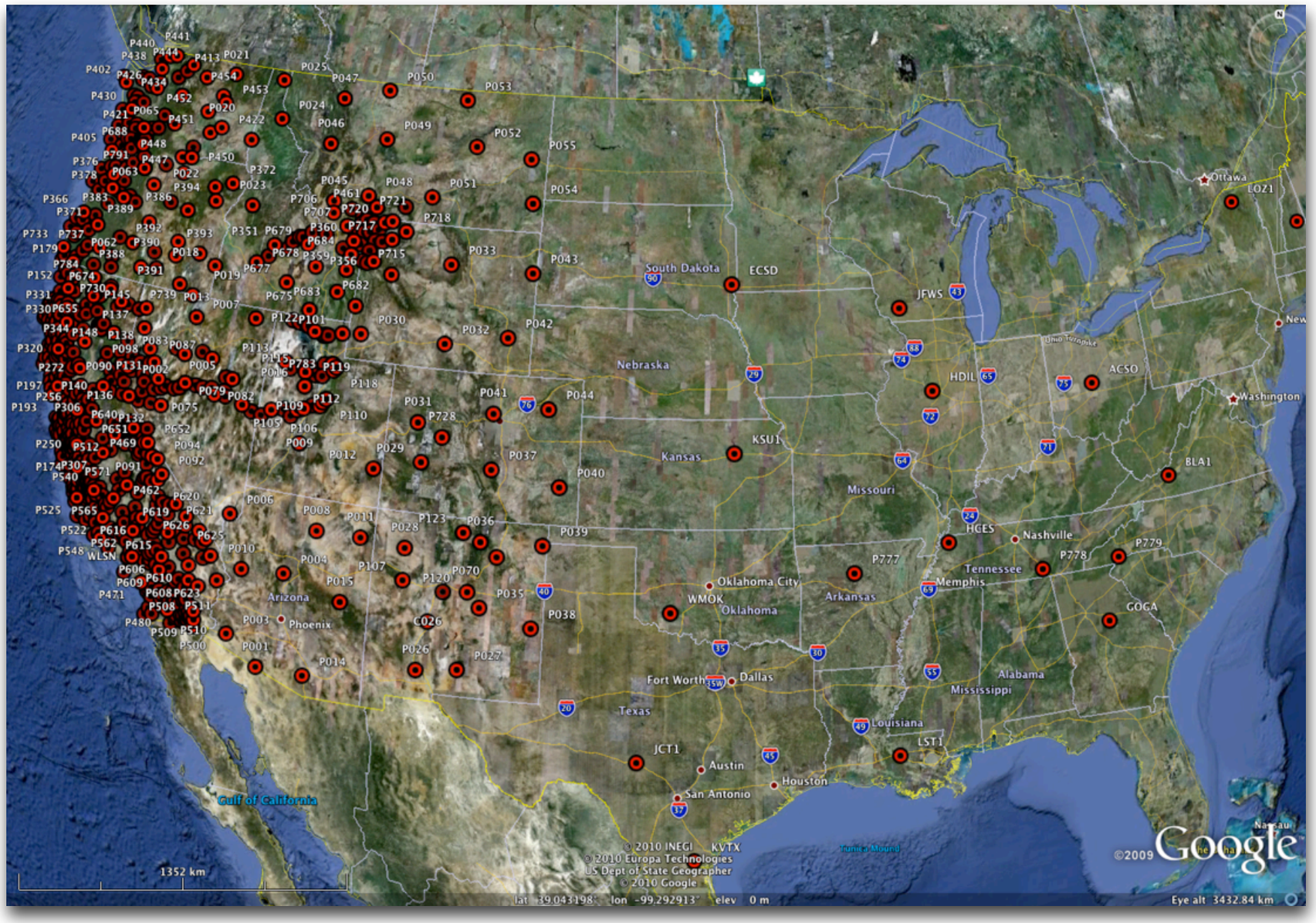


Open Data Sharing

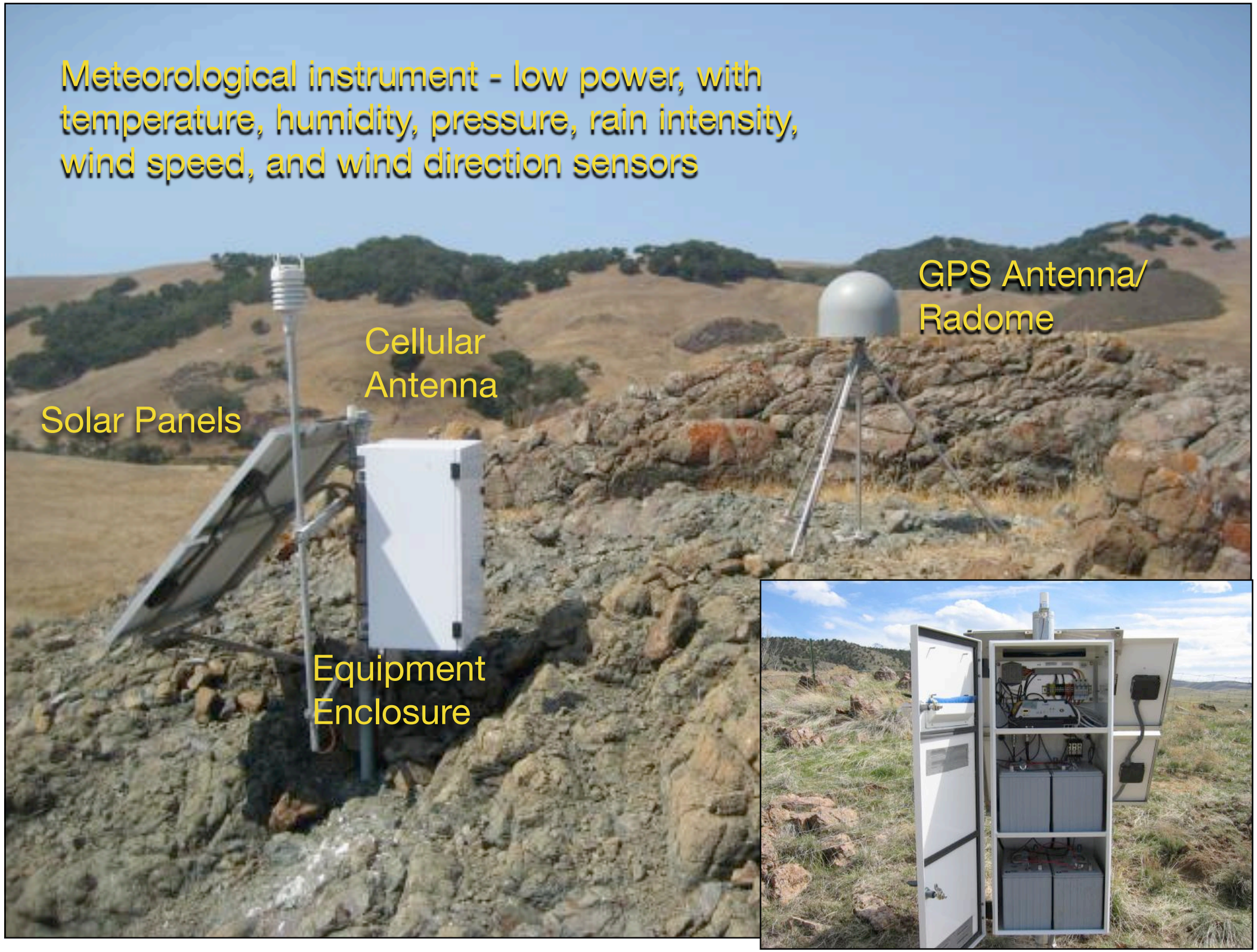
Plate Boundary Observatory (PBO):

1100 GPS stations, as well as other instrumentation in the Western US, including Alaska

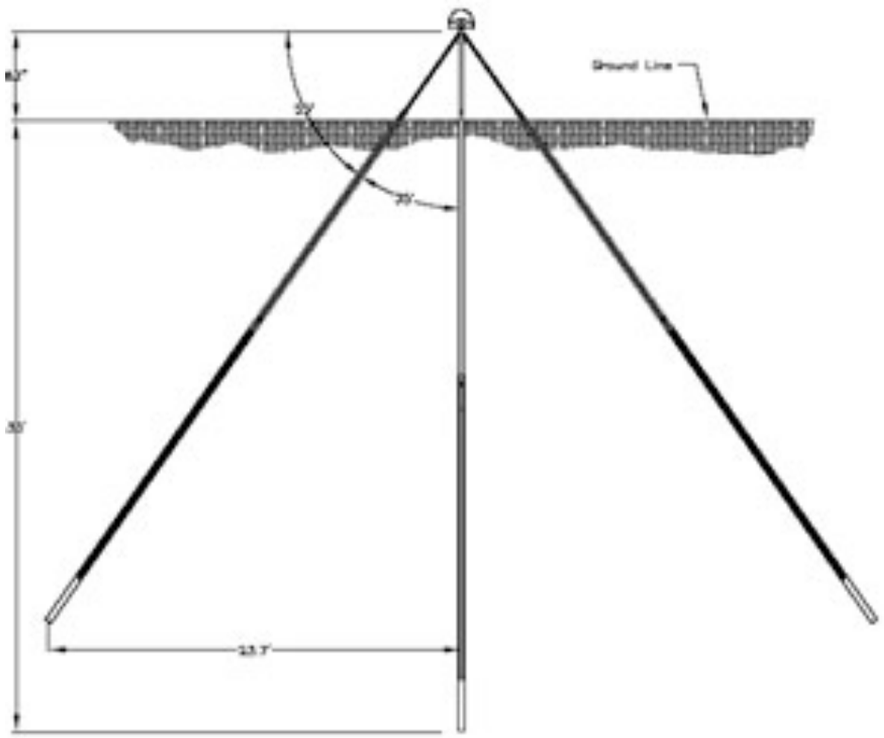
All freely available from UNAVCO Data Archive



The Co-located GPS / Met Station



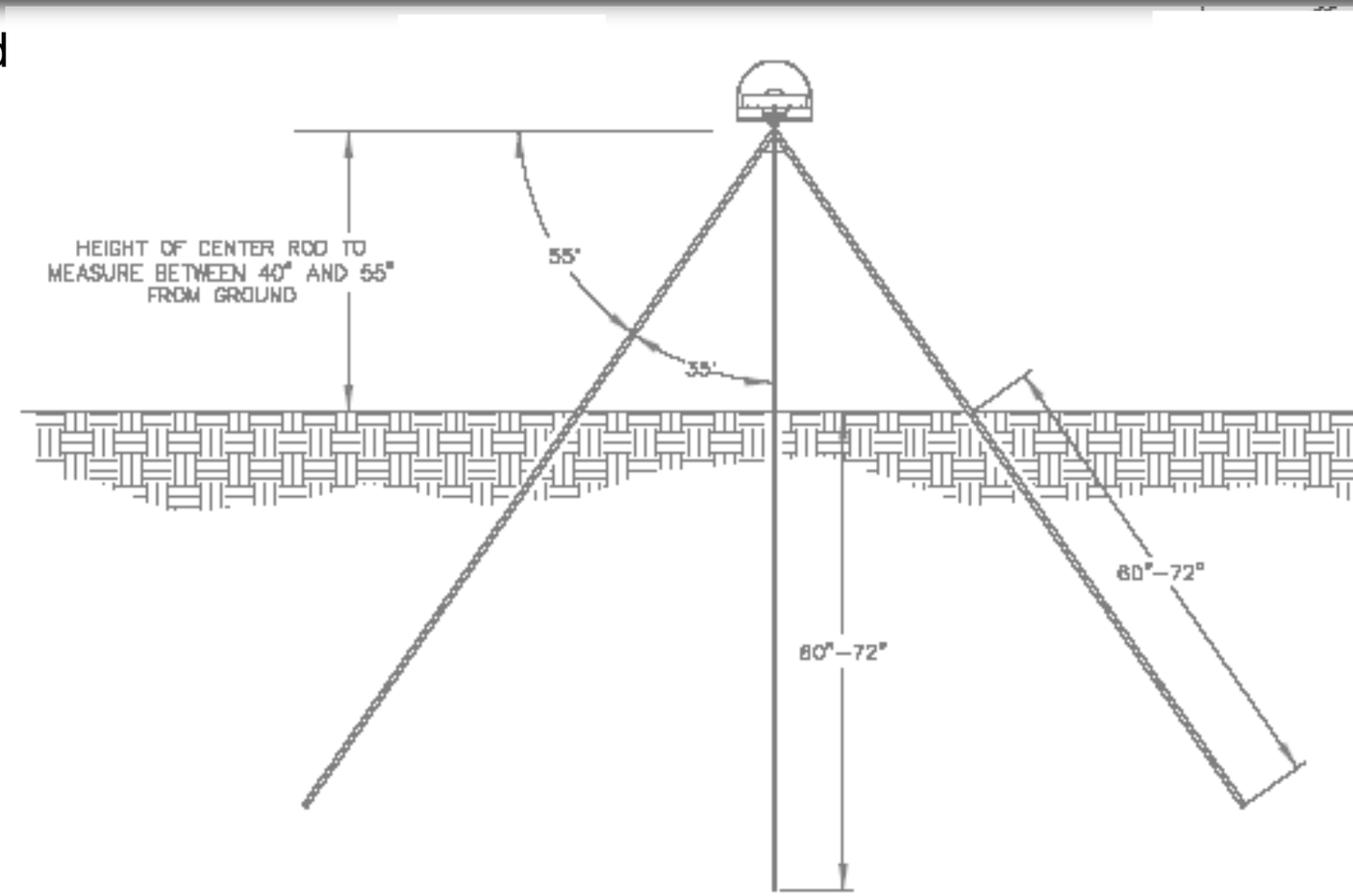
Deep Drilled Braced Monument

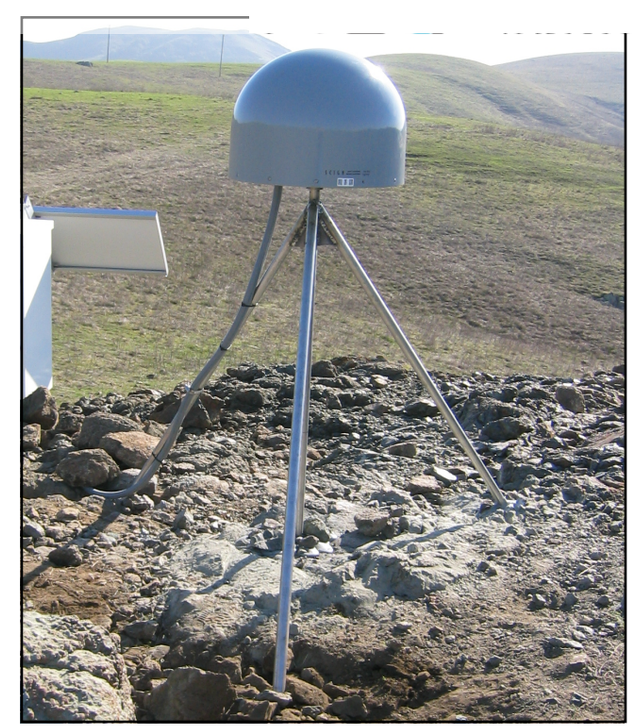


- Each hole is 4.5” diameter, 35 feet deep
- 5 legs - 1 vertical, 4 angled
- Anchoring legs meet at a single point on the main vertical leg, at an angle of 55 degrees
- Legs are constructed from two 20’ sections of 1.25” SS or galvanized schedule 80 steel pipe
- Holes are generally drilled with a “blasthole” type crawler drill, hammer or auger style drilling is used
- Legs are holes are filled with expanding grout
- The top 12-14 feet of hole is cased in PVC and foam
- At the intersection point, the entire structure is welded together and gusseted.

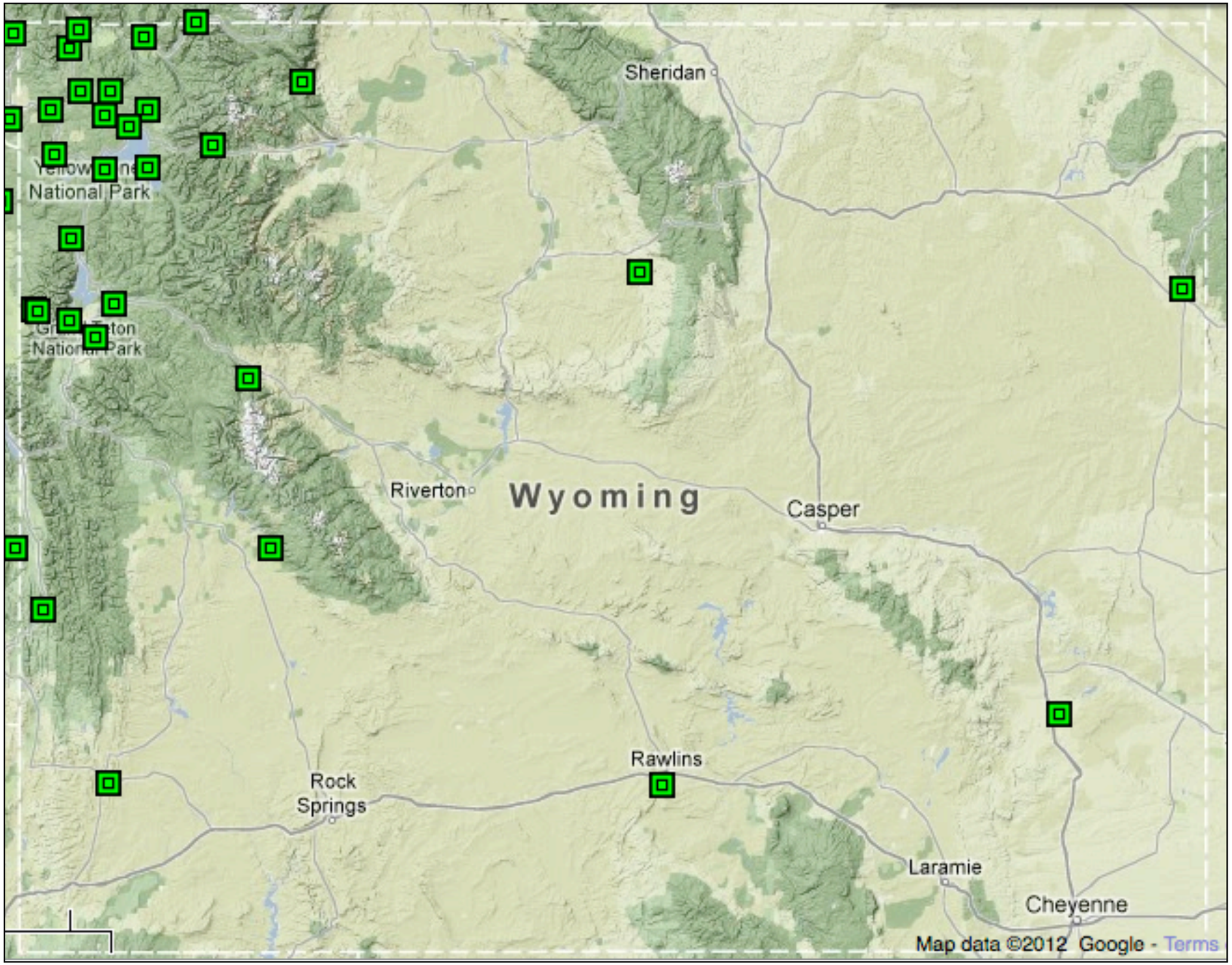
Short Drilled Braced Monument

- SDBMs are only installed in competent, exposed bedrock
- Each hole is 1 5/8” diameter, 5-6 feet deep
- Monuments have 4 legs
- Anchoring legs meet at a single point on the main vertical leg, at an angle of 55 degrees
- Legs are made of machined 12 foot 1” SS rods
- Holes are generally drilled with hand operated hammer drill
- Holes are filled with anchoring epoxy before the legs are inserted
- At the intersection point, the entire structure is welded together and gusseted.
- SDBM tools, equipment and materials can be easily transported via helicopter or short hike.



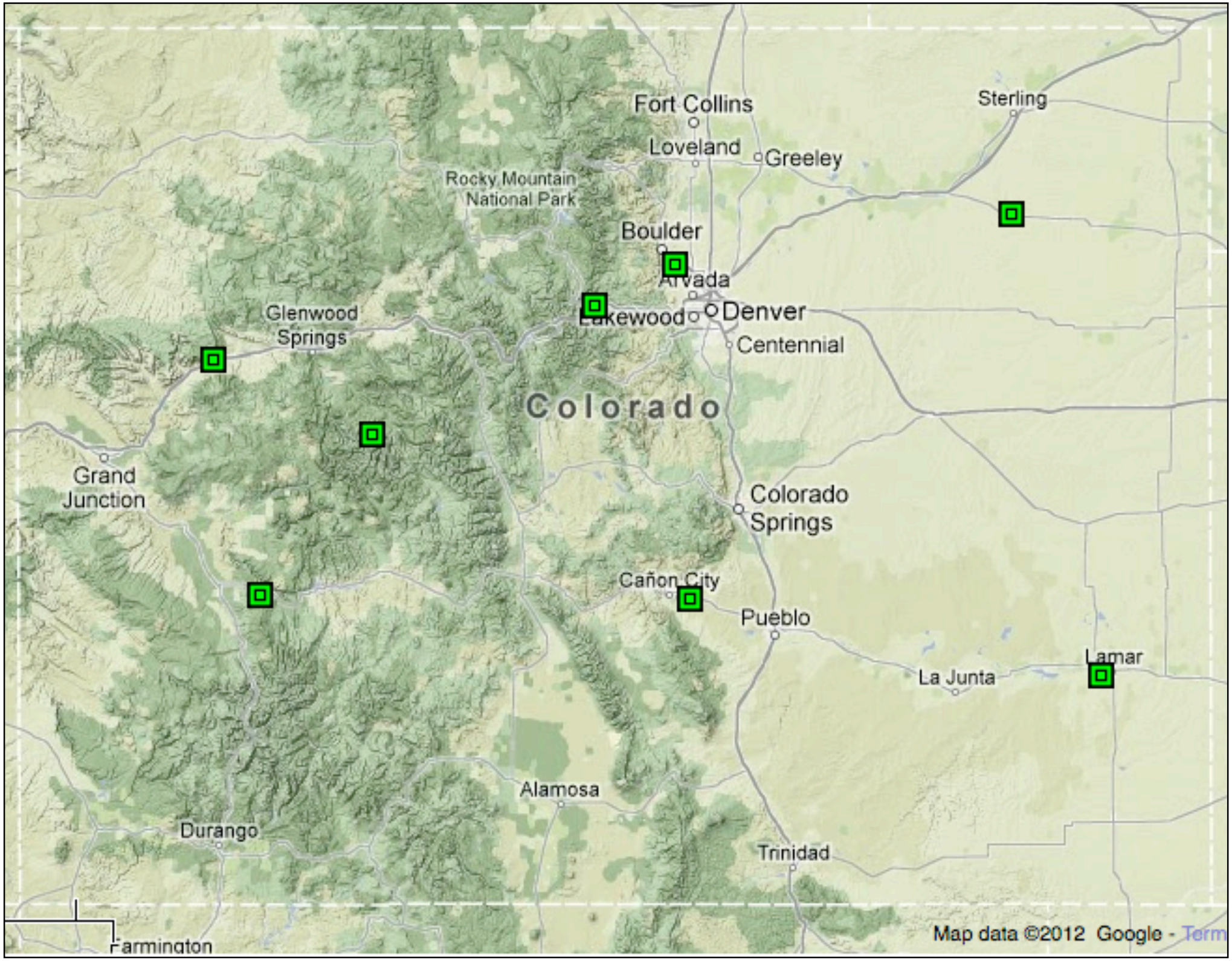


28 PBO Stations - Wyoming



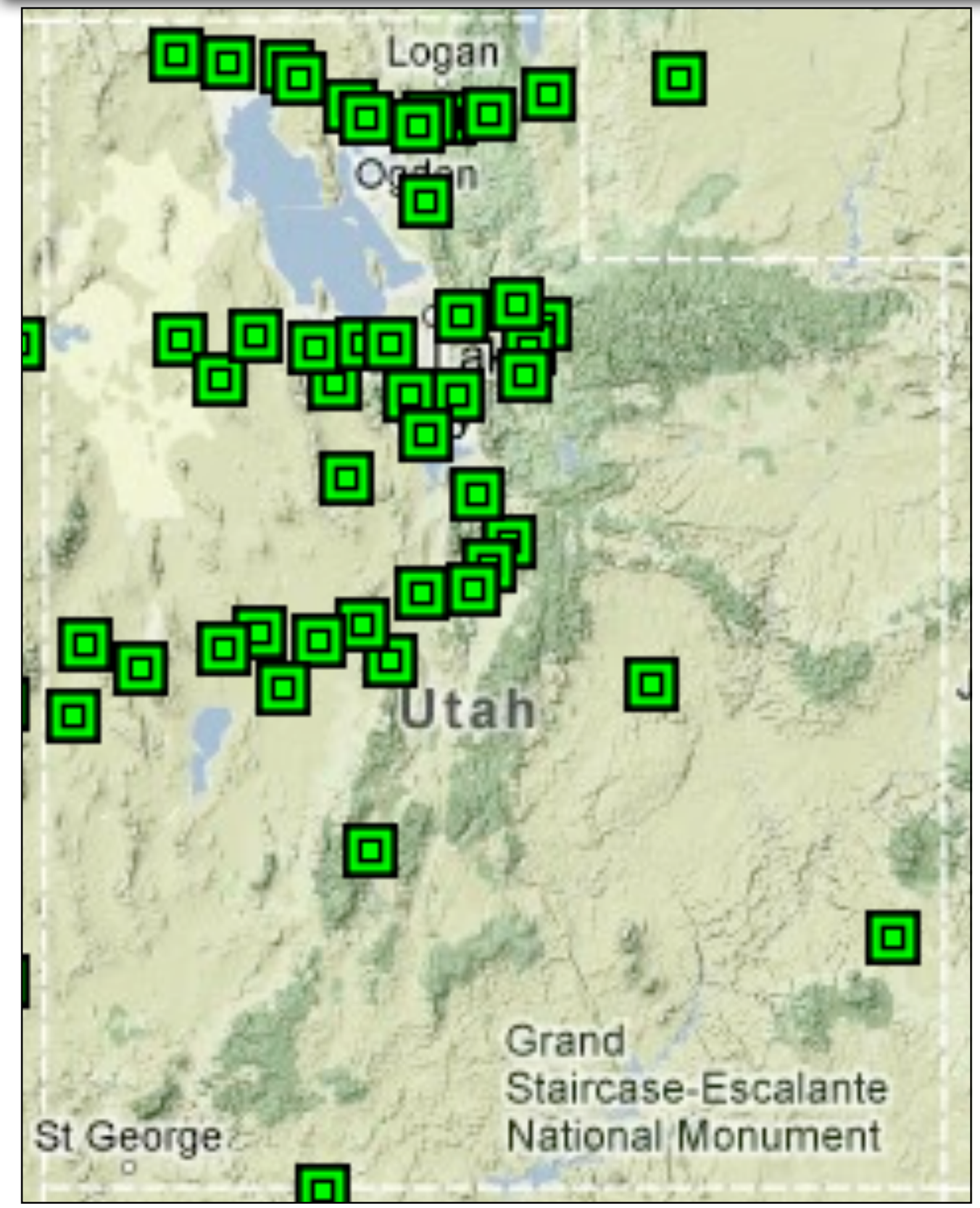
28 PBO Stations - Wyoming

8 PBO Stations - Colorado

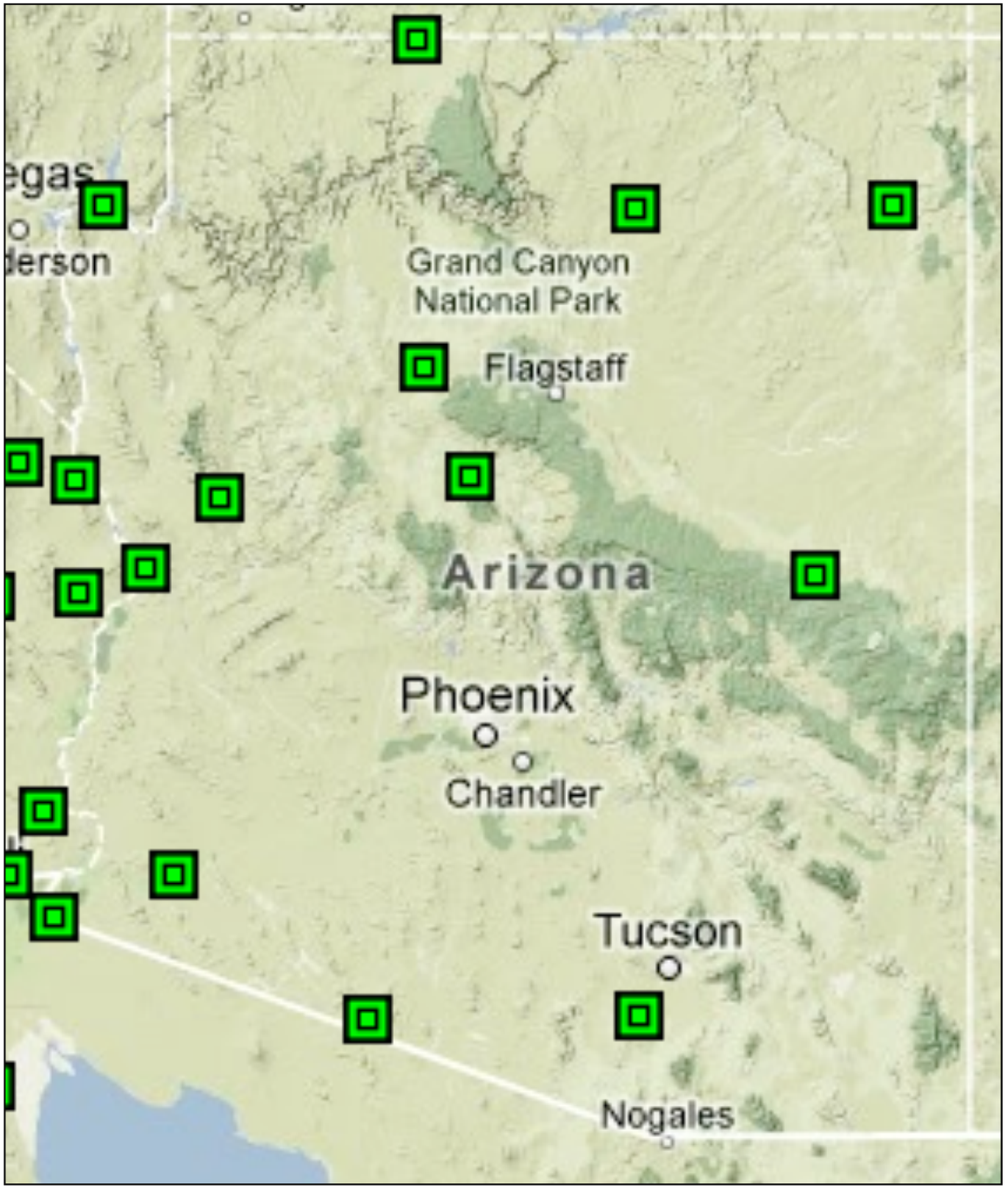


Montrose, CO

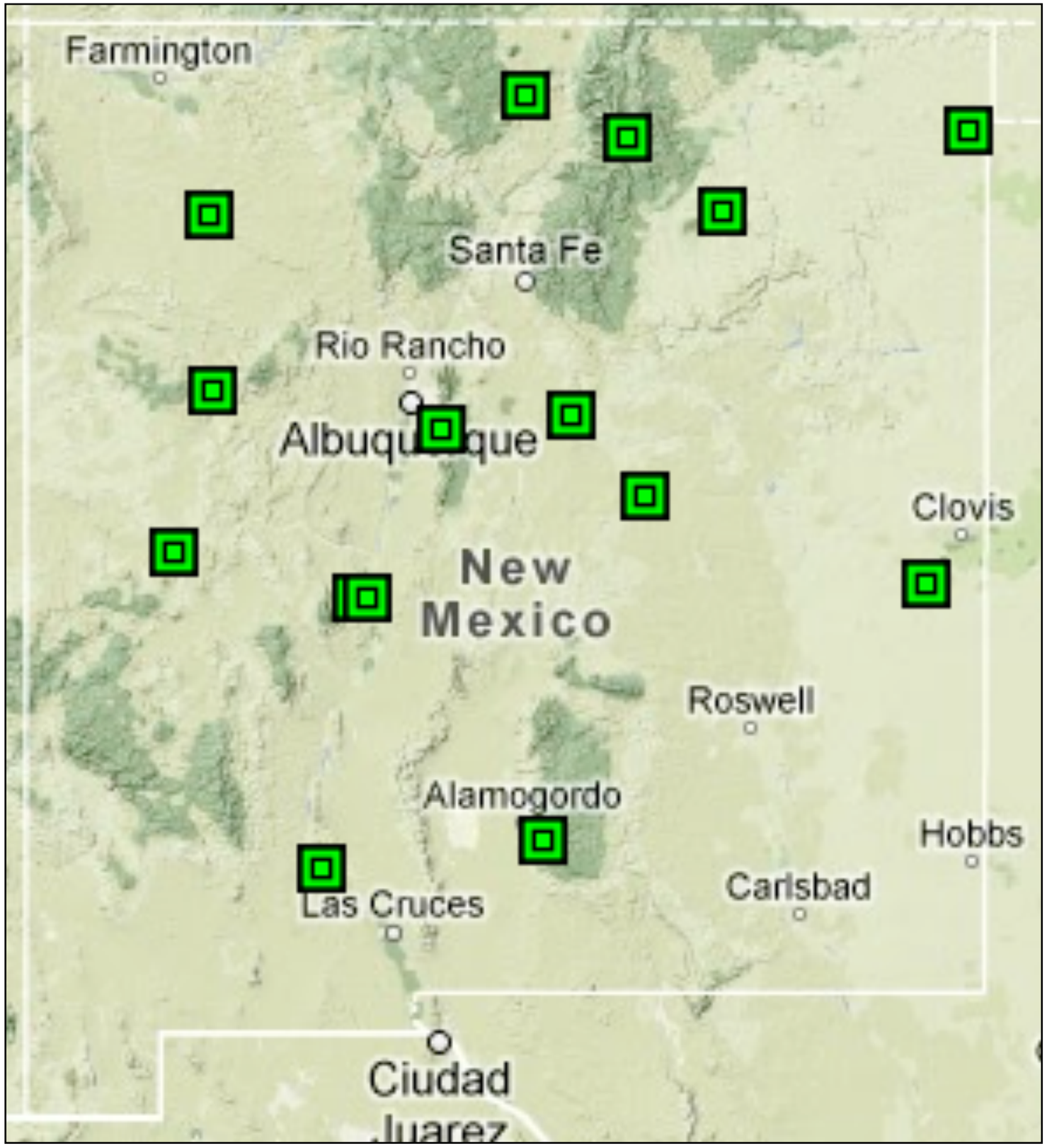
46 PBO Stations - Utah



12 PBO Stations - Arizona



13 PBO Stations - New Mexico



Rio Grande Rift Project

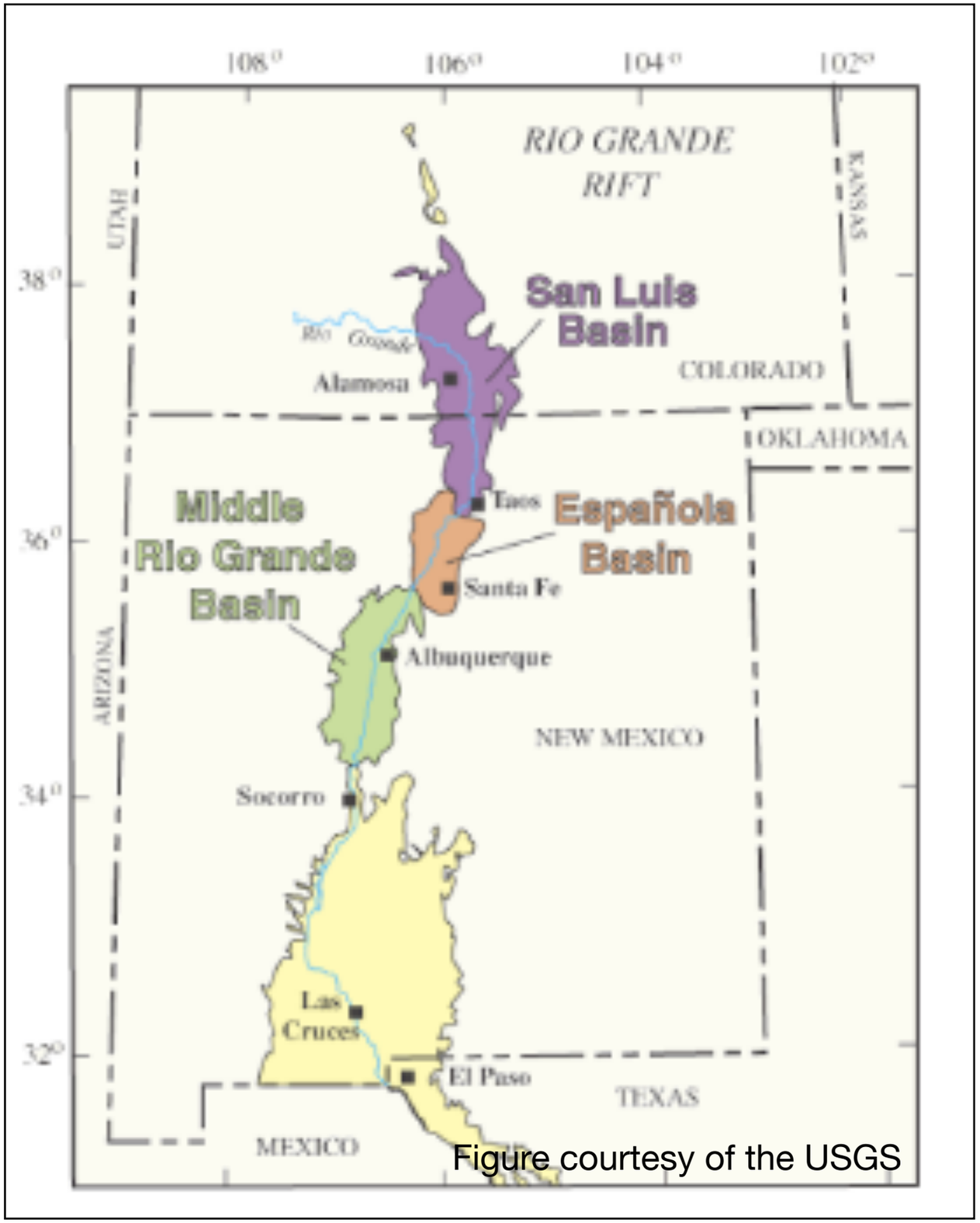


Figure courtesy of the USGS

- Funded by the National Science Foundation through the EarthScope Program
- Collaboration between University of Colorado and New Mexico Tech
- Principal Investigators: Dr. Anne Sheehan, Dr. Steve Nerem, Dr. Mark Murray
- A rift is a thinning of the lithosphere. Characterized by basins bounded by faults.
- The project uses GPS to measure the N-S variation in deformation.

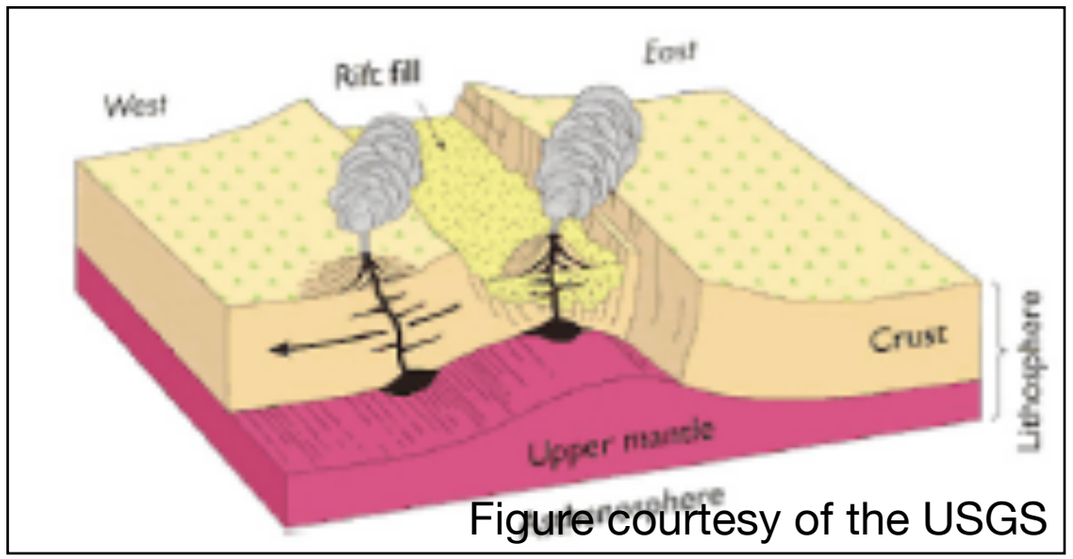
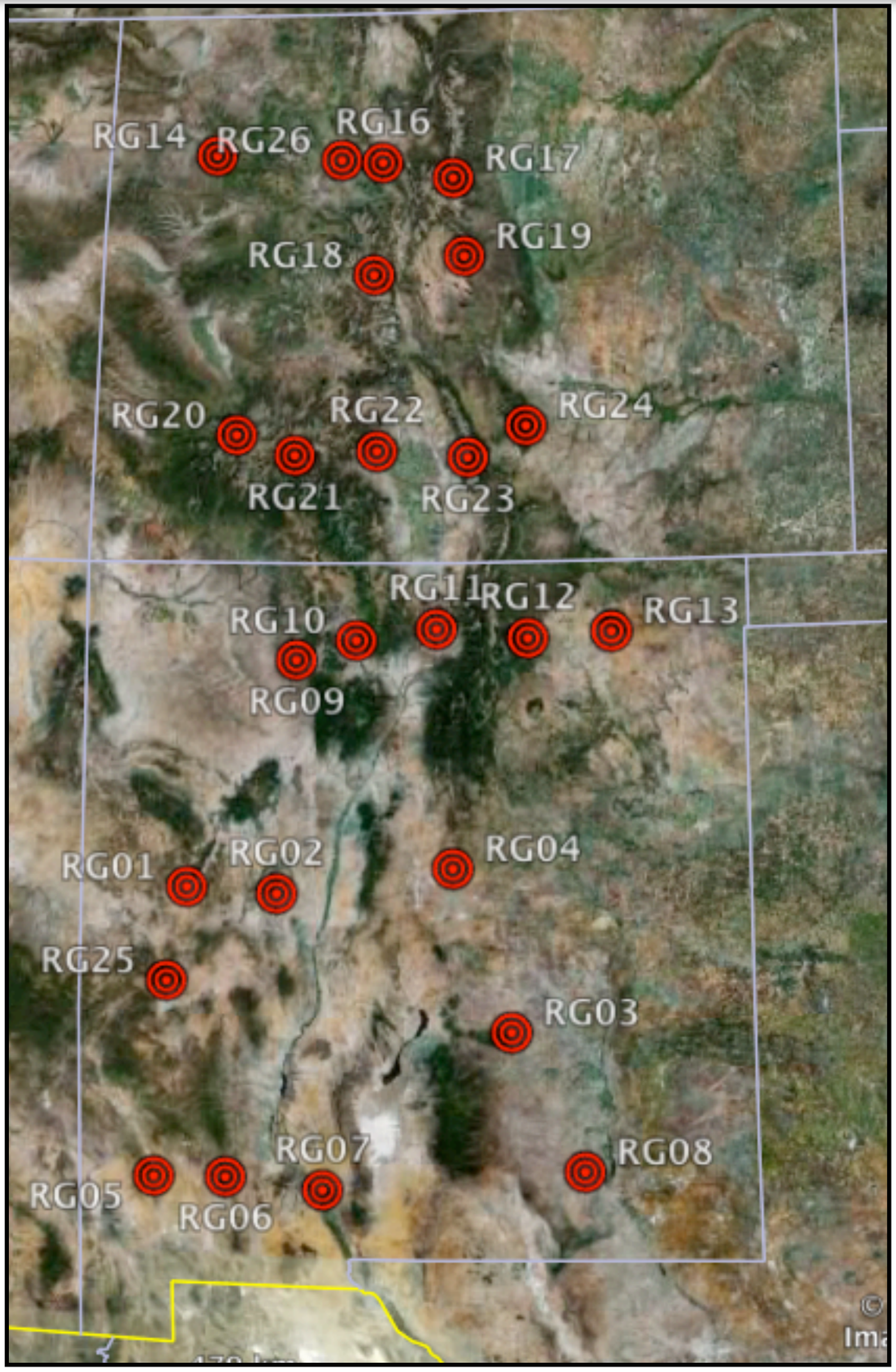


Figure courtesy of the USGS

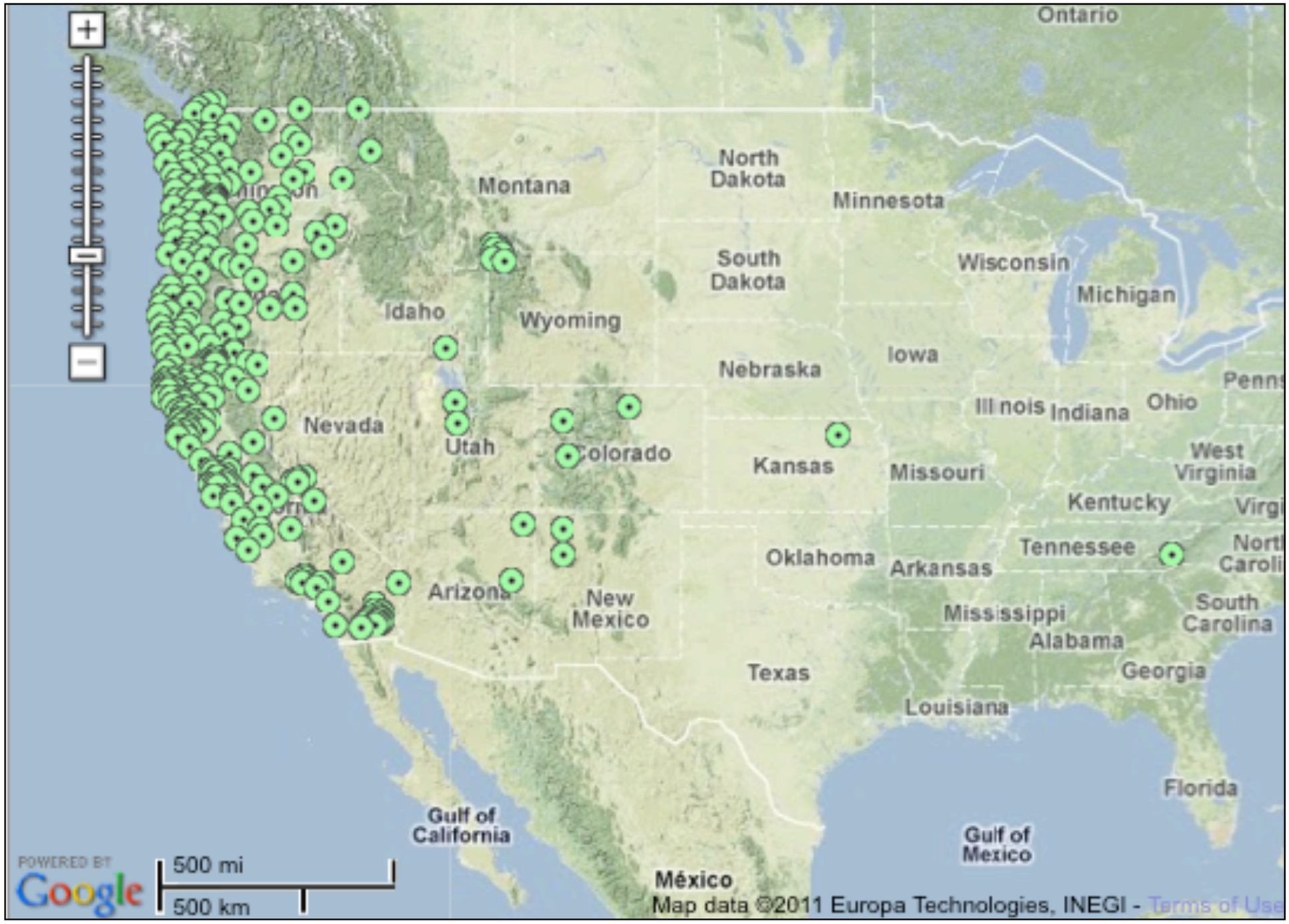
Rio Grande Rift Stations in New Mexico



- New Mexico - 14 GPS Stations
- Colorado - 11 GPS Stations
- Network consists of short drilled braced monuments and single pillar monuments
- Most sites do not have data communications, manual downloads only
- Standard data files - 24 hour files, 30 sec sample rate

High-Rate Realtime GPS in The Plate Boundary Observatory

348 of 1,100 GPS Stations Streaming 1-Hz Data



- The standard PBO data: 15 sec GPS data, Hourly and 24 hour files, with buffered higher rate data
- BINEX and RTCM data streams available at some stations
- Mean Latency for Realtime Network in September => 0.54 seconds
- Mean Daily Data Completeness for Realtime Network in September => 85%

Thank You For Your Attention!

For More Information
About Earthscope and
The Plate Boundary
Observatory:
www.earthscope.org

To Download PBO Data:
http://facility.unavco.org/data/dai2/dai2.html

To Collect High-Rate Data Streams:
http://pbo.unavco.org/data/gps/realtime

Targeted Experiments

Why High-Rate GPS Data?

- **Event Response**
  - Earthquakes, Volcanoes

PBO and COCONet will download 15 sec data in 24-hour files; However, 1-Hz and 5-Hz data buffers can be downloaded in the event of an earthquake.

- **Kinematic Surveying**
  - Base Station should collect as high if not higher-rate than the roving receiver

- **Airborne Platform Positioning**
  - LIDAR, Airborne Gravimeters, Airborne Photogrammetry

PBO Data Products team responds to several of these types of requests per month for temporary higher rate data to support these types of surveys.

- **Targeted Long-Term Research Experiments**
  - Soil Moisture estimation

How Much Did It Cost?

- Construction phase of all of PBO was $100 million over 5 years.
- GPS component ~$57 million. On average $51.8 k per station including siting, recon, permits, installation, data flow, data processing, and personnel.
- Ongoing operations and maintenance is $10.2 million per year for 1200 stations.
- GPS component ~$7.1 million per year or ~$6.5k per station per year including all repair parts and field visits, data flow, data processing and personnel.
- O&M staffing. ~1 field FTE per 110 stations. ~3 data products (data flow, processing, distribution) FTE per 500 stations.

Why Realtime GPS Data?

- Realtime kinematic (RTK) surveying

- Realtime data adds to the quality of the research immediately following an event

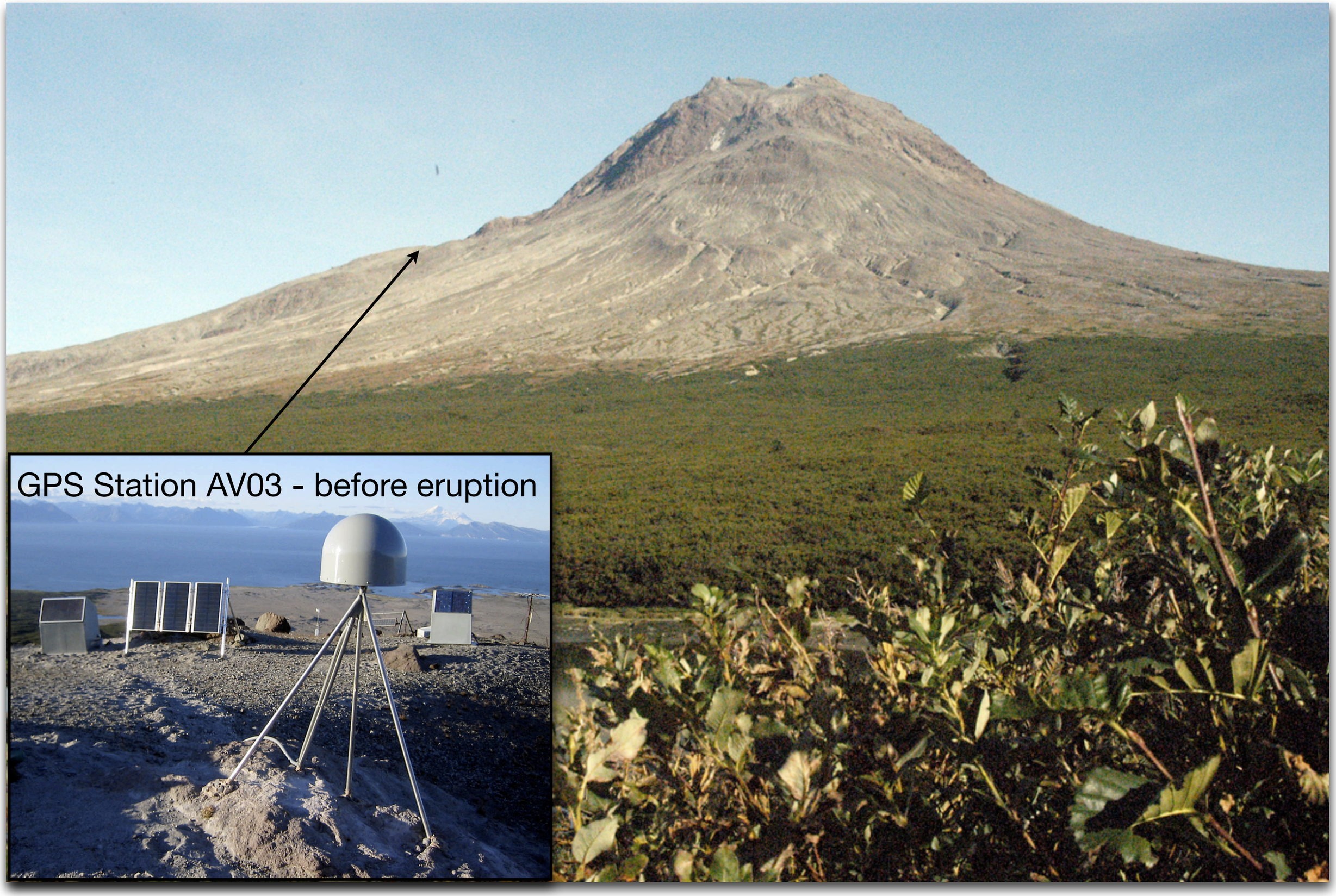
- Especially when combined with seismic data, high-rate realtime GPS data can provide faster earthquake source model calculations for Tsunami and Earthquake Early Warning Systems

- Volcanic Events: Allows the retrieval of GPS data in the seconds before an eruption, which can be the most scientifically valuable data

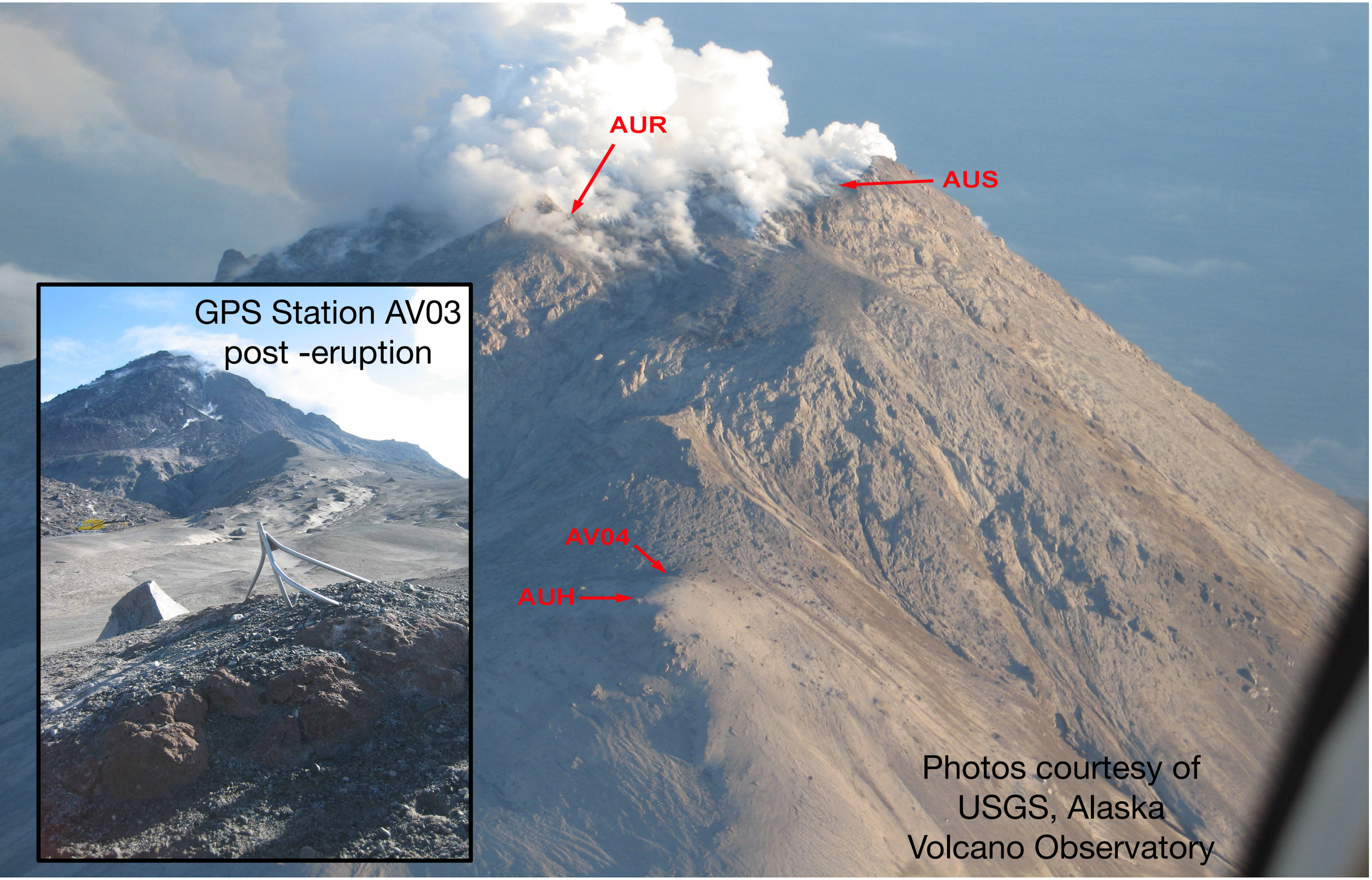
- Atmospheric Events: Can lead to improvements in hurricane intensity models and improved forecasting

- Collection of GPS realtime data streams is more efficient than the file-based data collection paradigm

Augustine Volcano - August 2004



Augustine Volcano - January 2006



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Governing Data Principles

- Central data archiving by an organization committed to free and open data sharing
- Robust metadata management and data processing using open and standard procedures, with open distribution of results
- Design dataflow to accommodate future bandwidth needs: Collocated stations, higher data rates, additional GNSS observables
- Include realtime streaming capability everywhere it is possible