GPS Reveals Slow Movement in Western US

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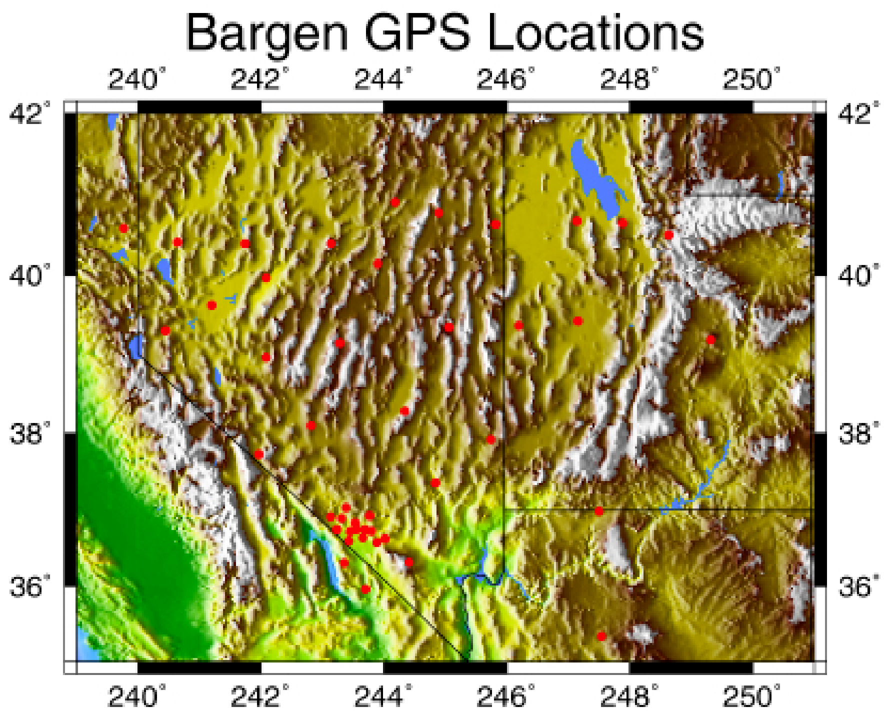
Right now, under your feet, the earth is moving. The land we live on lies on top of plates that slip and slide around the surface of the earth at speeds too slow to perceive. And on rare occasions, the land takes us by surprise and moves quickly, in what we call an earthquake.



Map of the BARGEN GPS sites. The map shows the alternating basins and ranges (long white features) that dominate the earth's surface in the western US.

The question for modern earth scientists is deceptively simple: how do we measure the speed of the earth's movement? The answer to that question might someday be able to help us predict earthquakes and prevent related tragedies. But it is also an elusive question that geologist Brian Wernicke, of the California Institute of Technology (CalTech), and geophysicist Jim Davis, of the Harvard-Smithsonian Center for Astrophysics have been pursuing. And if all goes well in coming years, they (and others who work on similar questions) are going to be one giant step closer to the answer.

Wernicke, Davis and many of their colleagues are waiting to hear if Congress decides to fund EarthScope, a multi-year, multi-university project to learn more about how our continent formed and continues to evolve. If funded, one focus will be to better measure movements of the earth's surface along the western coast of North America. It would bring together all the scientific groups now independently measuring the earth's movements in that area, and give them the tools to measure it better together.

Dr. Wernicke's area of study is the Basin and Range, a region that reaches from eastern California to central Utah, and from southern Idaho into the state of Sonora in Mexico. The Basin and Range has long been of interest to scientists because it is a place where the earth is stretching apart, but it's not stretching in a single location (as is common elsewhere). Instead, there are many small stretch marks or extensions, throughout the region.

You can almost see these stretch marks if you look at a topographic map of the Basin and Range. The entire region is composed of alternating strips of mountains and flat basins - and it is these flat basins that scientists believe are actually stretching or pulling apart.

But scientists do not completely understand why the Basin and Range acts the way it does. They know it is a region where two of earth's tectonic plates are moving away from each other, but they do not know why it is stretching in many different places as opposed to creating one big opening, or rift.

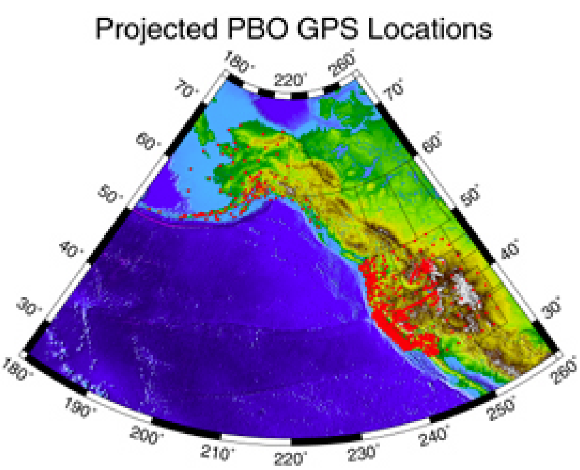
To better understand this, Wernicke and Davis track the movement of the earth in this region using an array of carefully placed GPS (Global Positioning System) instruments. Each GPS is a device that looks like a giant camera tripod supporting half of a round metal ball, and is anchored below the surface of the earth at about 10 m deep (that is about three floors of a building).

The ground based GPS instrument receives signals from satellites in orbit and uses those signals to calculate its exact position on the earth (working in much the same way as the handheld GPS receivers so popular among outdoor enthusiasts). Because each GPS device is anchored below the surface of the earth, over time the measurements can reveal whether or not the instruments (and therefore the earth) are moving together or apart, and at what speed. The anchoring depth also helps filter out some of the signals made by humans on the surface that can create false or insignificant measurements of movement.

Since about 1997, the Wernicke-Davis team has operated approximately 50 GPS instruments lined up east to west along latitude 40 degrees north in the Basin and Range, an array known as BARGEN (the Basin and Range Geodetic Network). With this they have learned that the earth there moves about 1-2mm a year, on average.

But the BARGEN study area is small when compared to the western coastline of North America - and EarthScope is thinking big. Ultimately, EarthScope seeks to outfit the western United States with GPS instruments placed approximately 150 km apart as part of a project called the Plate Boundary Observatory (or PBO for short).

The name of the project stems from the geology of the area. Roughly along the western coast of North America, two of the plates slipping around on the surface of the earth butt up against each other, one sliding beneath the other or past it. Scientists call this a plate boundary. As a result of the plates sliding against each other, many earthquakes happen in these areas and they are typically good places to study.



Map of GPS sites for the EarthScope Plate Boundary Observatory. Red dots show locations of GPS instruments. Click on the map for a larger image.

Altogether there are 5 major collections of GPS instruments operating in places along the plate boundary, and each has contributed to our understanding of the earth in those particular places. Because the groups are largely independent and their instruments are far apart on the continent, scientists are forced to speculate about what is happening with the earth in between. And although they all use GPS instruments, slight differences in set up and operation make it hard to compare data from one site to the next.

The main contribution of EarthScope will be to bring together the operators of these independent arrays and help them make the instruments they use more consistent and therefore more comparable. And it would multiply many times over the number of instruments currently in use.

Right now there are about 400 GPS instruments clustered in groups throughout the western United States, often focused on specific features of interest: the Basin and Range, Yellowstone National Park, the Bay Area, Southern California (Los Angeles), and the northwest (the Cascades Mountain Range). While these are independently operated, UNAVCO, Inc. ,is the glue that brings all these campaigns and their data together for the GPS community. With EarthScope's and UNAVCO's help, scientists will have 900 more instruments to distribute along the plate boundary, greatly refining the measurements and conclusions that can be confidently created.

Initially, scientists hope to learn about the movements along the plate boundary, and eventually refine our knowledge of earthquakes. As Wernicke says, "The physics of earthquakes are still much of a mystery. EarthScope will give us a new set of glasses on the whole problem."

And many earth scientists agree. Paul Silver, the Steering Committee Chair for the PBO portion of EarthScope and a geophysicist himself, says this project will help earth scientists make dramatic progress towards answering basic scientific questions like "When and where will the next volcano erupt?" Silver explains that a major piece of the puzzle that scientists want to better understand is time. That is, the timing of events on the surface (like earthquakes and volcanoes) in relation to plate movements.

Thanks to Wernicke and the BARGEN array we have some notion of time in the Basin and Range, but many scientists believe there is so much more we can learn and are eager to get started.

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