

Using GPS to Study Plate Tectonics



Figure 1. Photograph of a high-precision GPS station.

The **global positioning system (GPS)** is a fleet of 29 satellites that are orbiting our planet approximately 11,000 miles above Earth's surface. A position can be calculated using three satellites (Figure 2, right), plus a fourth because of clock imprecision. You are probably familiar with hand-held GPS units that people use while driving and hiking. These units are accurate to approximately 1 meter. In contrast, a high-precision GPS can calculate a position to less than the nearest centimeter!

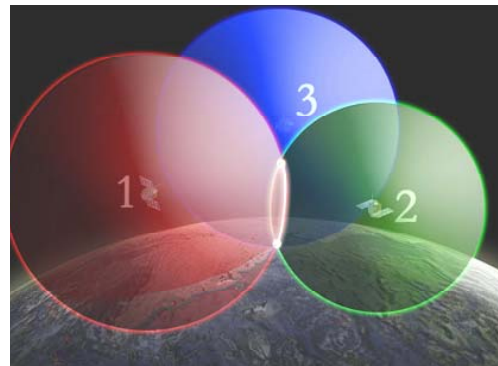


Figure 2. Illustration of calculating a position on Earth's surface using GPS satellites. Figure courtesy of NOAA.

The theory of **plate tectonics** explains that Earth's crust and upper mantle are split into a series of rigid plates (Figure 3). Like moving puzzle pieces, the plates move slowly and interact with one another at plate boundaries. Plates move apart at divergent boundaries, come together at convergent boundaries, and slide past one another at transform boundaries. A variety of exciting geologic phenomena including earthquakes, volcanic eruptions, and mountain building occur at plate boundaries, all of which cause the Earth's surface, the crust, to **deform** (change.).

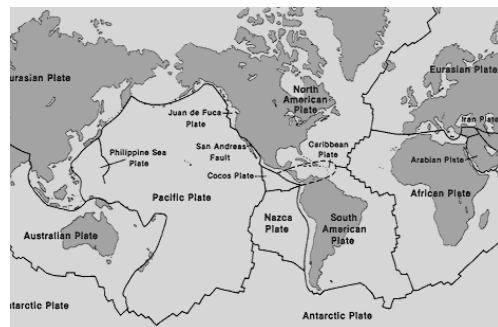
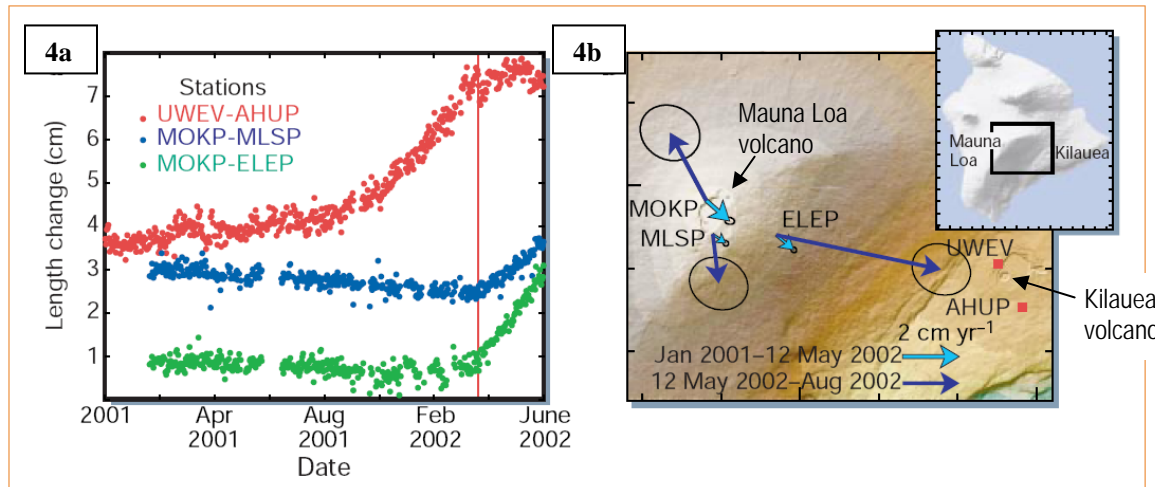


Figure 3. Simplified diagram of plates. Figure courtesy of USGS.

When deformation occurs at a point on Earth's surface, the point's position changes. This position change can be measured using high-precision GPS instruments. Earth scientists use these data to record how much and how quickly Earth's crust is changing because of plate tectonics and to better understand the underlying processes of the deformation.

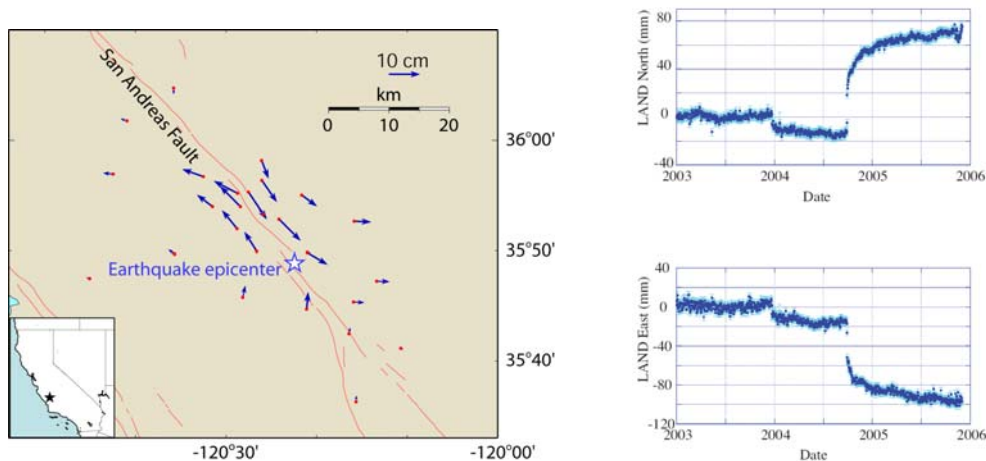
Application of GPS Measurements to Studying Earthquakes and Volcanoes

Monitoring volcanic deformation in Hawai'i



Figures 4a and 4b. By looking at the position of points on the Earth's surface measured with GPS over time, scientists can see changes in the crust's deformation. For instance, at Mauna Loa volcano in May 2002, GPS stations on opposite sides of the summit started moving away from each other, indicating that the volcano was inflating. From Miklius and Cervelli, *Nature*, 2003.

Measuring displacement due to a recent earthquake in Parkfield, CA



Figures 5 (left) and 6 (right). When an earthquake occurs, the ground on either side of the fault moves instantaneously, sometimes causing strong shaking. GPS measurements enable scientists to map these displacements (Figure 5) and determine how much slip took place on the fault and where slip occurred. Although we cannot feel it, the crust on either side of the fault continues to slip after the strong shaking is over, sometimes for several years. Scientists can record this motion with GPS as well (Figure 6).

Figure credits. 1: UNAVCO. 2: NOAA NOS Education Discovery Kits- Geodesy.
3: <http://pubs.usgs.gov/gip/earthq3/what.html>. 4a and 4b: Miklius and Cervelli, 2003. 5 and 6: J. Murray.