GPS Strain & Earthquakes Unit 5: 2014 South Napa earthquake GPS strain analysis – student reading

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This page is meant to provide a brief summary of the event. More extensive resources can be found on the SAGE teachable moment page (http://www.iris.edu/hq/retm/2559), the GAGE data event response page (http://www.unavco.org/highlights/2014/south-napa.html), and the USGS event page (https://earthquake.usgs.gov/earthquakes/events/2014napa/).

On August 24, 2014 a M_w 6.0 earthquake shook the San Francisco Bay Area. This was the largest earthquake in the region in almost 25 years. The earthquake epicenter was located south of Napa, CA and north of San Pablo Bay (Fig. 1). This event fell within relatively dense arrays of permanent GPS stations and seismometers and provided an excellent opportunity to evaluate rapid response algorithms currently under development.

The focal mechanism (Fig. 1) for the South Napa earthquake shows a classic strike-slip radiation pattern associated with either right later slip on a fault trending 345° and dipping 85°, or left lateral slip on a vertical fault trending 75°.
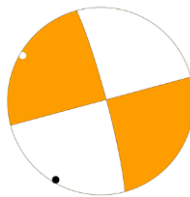

Figure 1. Focal Mechanism for the South Napa earthquake (USGS event page, 2014)

A finite fault model derived from regional seismic data indicated that the rupture occurred on a right-lateral NNW striking fault (USGS event page, 2014), which is not surprising given the regional geology. The maximum slip in this models was ~ 1 m and occurred below the earth's surface. Geologic mapping has confirmed the presence of surface rupturing slip along the West Napa fault (Fig. 2).

Figure 2. Surface rupture along the West Napa fault showing ~40 cm of right lateral offset of a grape trellis (Photo Thomas Holzer, USGS event page, 2014).

Rapid processing of GPS time-series data at the Nevada Geodetic Laboratory (2014) captured the crustal deformation signal of the earthquake (Fig. 3). The deformation pattern shows opposite sense of motion for stations to the east and west of the epicenter, again consistent with right-lateral slip along the West Napa fault.
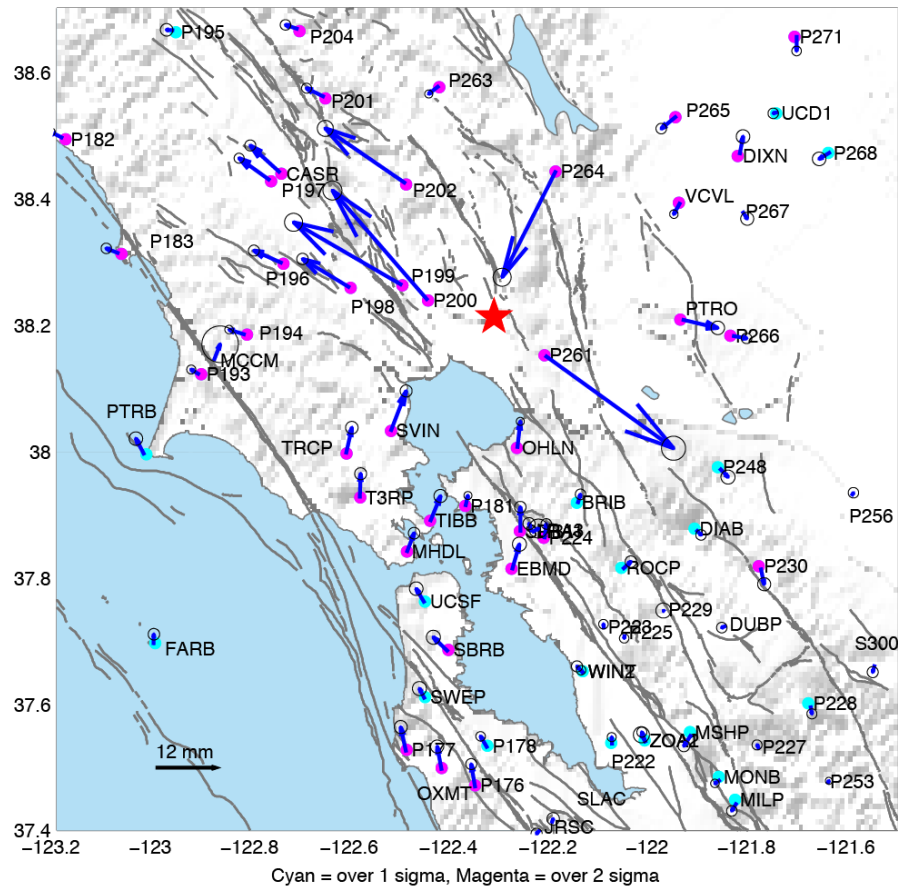

Figure 3. Coseismic offsets (displacements) of GPS stations estimated two days after the event using 24 hours of post-earthquake data. The offsets were estimated as the difference between the means of the coordinates for time intervals before and after the event. Uncertainties in the offsets were estimated using the scatter of each time series. Cyan and magenta dots in the vector plot indicate displacements that are greater than the 1-σ / 2-σ uncertainty, respectively (Nevada Geodetic Laboratory, 2014).

The time series for individual GPS stations (Fig. 4) show the relatively constant velocity of the stations prior to the earthquake, interrupted by a sudden jump when the earthquake occurred. In this activity we will explore both this slow (interseismic) deformation and the nearly instantaneous (coseismic) deformation that occurred due to the earthquake.
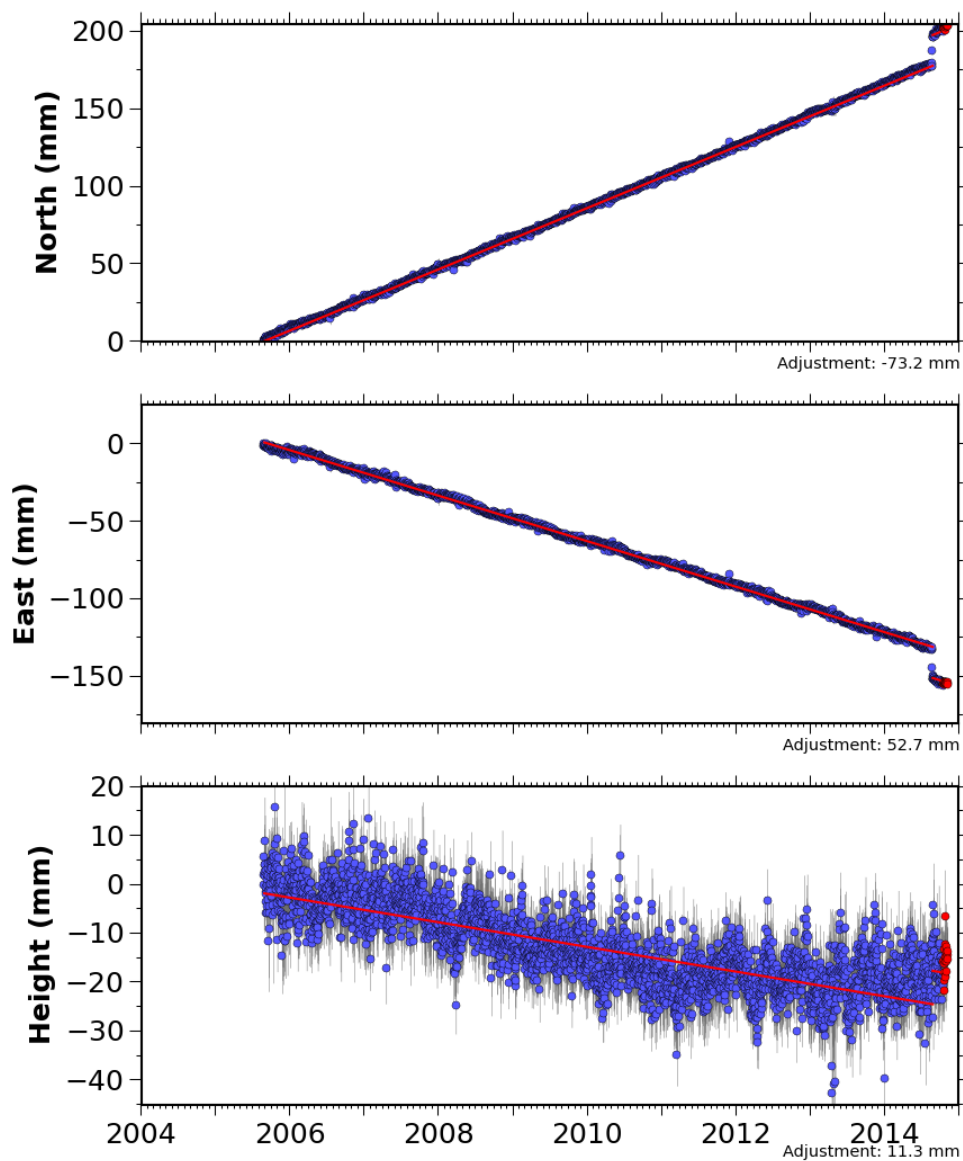
Figure 4. Time series for Network of the Americas (NOTA) GPS station P200. South Napa earthquake occurs near the right end of the plot in August 2014, just before the red points [https://www.unavco.org/instrumentation/networks/status/pbo/overview/P200]