A Reprocessed GPS Velocity Field for the Western US

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Goal

- Collect and reprocess GPS data in the western US to produce a unified crustal motion map.

- All GPS data are reprocessed uniformly using the best and latest models and techniques, such as the most updated data processing softwares, satellite and receiver antenna phase center models, ocean tides and atmospheric delay models, and geodetic reference frame, to ensure the best precision of the solutions.
GPS Data

• Campaign GPS data archived at UNAVCO, SCEC, NCEDC, and USGS data centers (more than 30,000 RINEX data files observed during 1993-2011 period at more than 3700 campaign sites)

• 1300 continuous GPS sites
GPS Data Processing

• GAMIT 10.40 was used to produce regional daily solutions, which were then combined with SOPAC daily solutions of global and regional continuous networks.

• Combined daily solutions were subsequently aggregated using the QOCA software to solve for station initial positions, secular velocities, coseismic jumps, and postseismic displacements modeled as logarithmic decay functions.

• To accommodate the colored data noise, station position perturbations of 1, 1, 2 mm²/yr were assigned for the east, north, and up components, respectively.

• Final solution was referenced to the ITRF2008 reference frame, then transferred to the SNARF reference frame realized by constraining network translation, rotation, and dilatation of north America fiducial sites to their SNARF model predicted values.
postseismic deformation

interseismic

coseismic
Station displacement model

\[ D(t) = D(t_0) + V(t - t_0) + \sum_i J_i H(t - t_i) \]
\[ + \sum_i P_i \log_{10}(1 + (t - t_i)/T) \]

- \( D(t_0) \): initial position
- \( V \): steady velocity
- \( J_i \): coseismic displacement of the \( i \)th earthquake
- \( H(t - t_i) \): Heaviside function
- \( P_i \): postseismic displacement of the \( i \)th earthquake
- \( T \): postseismic relaxation time constant = 10 days for southern California
COSEISMIC FIELD

1992 Mw7.3 Landers

1999 Mw7.1 Hector Mine
Postseismic Displacement Time Series

Landers

Hector Mine
Poseismic Displacement

1992 M7.3 Landers

1999 M7.1 Hector Mine
Solution

The final solution, after checking and filtering, has 2605 velocity vectors with horizontal uncertainties < 1.5 mm/yr, and ~1500 coseismic and ~1200 postseismic displacement vectors induced by eight strong earthquakes occurred during 1993-2011.
Summary

We collect and process GPS data observed in western US to produce a unified crustal motion map. We searched Campaign GPS data archived at the UNAVCO, SCEC, NCEDC, and USGS data centers, and obtained more than 30,000 RINEX data files observed during 1987-2011 period at more than 3700 campaign sites in western US. We also collected data from more than 1300 continuous GPS sites in the region. We use the GAMIT software version 10.40 to process regional data (campaign and continuous) to produce daily solutions of global and regional continuous networks. The combined daily solutions are subsequently aggregated using the QOCA software to solve for station initial positions, secular velocities, coseismic jumps, and postseismic displacements (modeled as logarithmic decay functions). The final solution is referenced to the ITRF2008 reference frame, then transformed to the SNARF reference frame realized by constraining network translation, rotation, and dilatation of north America fiducial sites to their SNARF model predicted values.

In our current solution we have incorporated all the aforementioned data collected 1993-2011, and are working toward to include all the pre-1993 data by the end of this year. Our current solution, after quality checking and filtering, has ~2600 velocity vectors, and ~1500 coseismic and ~1200 postseismic displacement vectors induced by eight strong earthquakes occurred during 1993-2011.

The secular velocity solution is presented as red arrows on the map to the right. Velocity solutions from other groups/studies are also plotted, to make comparisons and to fill in some regional holes for which we do not have the data in our current solution. These datasets are from the SCEC Southern California Crustal Motion Map version 4.0 (CMM4), 2011 PBO velocity solution (W. Hammond), 2012 Pacific Northwest network solution (R. McCaffrey), Panga Network solution, and 2012 SOPAC regional network solution (Y. Bock).

After screening out about 400 outlier sites from all the solutions, we are left with a dataset of about 4000 velocity vectors (with certain redundancy in it), representing a velocity field which is quite smooth and coherent. Velocity profiles across the entire plate boundary zone are plotted to reveal regional deformation pattern in details.