SCEC Annual Meeting 2010
Poster 1-152

# A Densified Geodetic Velocity Solution for the North San Francisco Bay Region

Michael A Floyd, Gareth J Funning, Brad P Lipovsky
*Department of Earth Sciences, University of California, Riverside, USA*

## Introduction

We present an expanded and updated velocity solution of 61 sites (excluding existing Plate Boundary Observatory sites and survey sites currently with velocity uncertainties of > 10 mm/yr) for the counties in the North San Francisco Bay area. These velocities are now reaching a level of maturity and precision that they may be used for meaningful analysis and incorporation into regional velocity solutions. We are concerned with the interaction of fault systems in the North Bay area, specifically the Rodgers Creek and southern Maacama Faults, which are thought to pose a significant potential hazard to the area. All data from the rapidly deforming area in The Geysers (see Figure 1) are excluded for the purpose of this presentation.

We acquired publicly-available and restricted data sets from a number of sources to augment our own data collection, listed in Table 1, below.

| Survey | Institution | Epoch |
|---|---|---|
| High-Precision Geodetic Network 1991 | Caltrans (SCEC) | 1991.1342–1991.6164 |
| The Geysers 1994/08 | Stanford (UNAVCO) | 1994.5991–1994.6155 |
| The Geysers 1994/09 | Stanford (UNAVCO) | 1994.7361–1994.7498 |
| The Geysers 1995 | Stanford (UNAVCO) | 1995.5909–1995.6108 |
| The Geysers 1996 | Stanford (UNAVCO) | 1996.7231–1996.7403 |
| High-Precision Geodetic Network 1998 | Caltrans (SCEC) | 1998.5548–1998.5712 |
| The Geysers 2000 | University of Utah | 2000.6926–2000.7117 |
| The Geysers 2001/04 | University of Utah | 2001.3137–2001.3329 |
| The Geysers 2001/09 | University of Utah | 2001.6918–2001.7411 |
| The Geysers 2006 | University of Utah/UC Berkeley | 2006.7575–2006.8096 |
| GeoEarthScope Northern California 2007 | EarthScope (UNAVCO) | 2007.2726–2007.2781 |
| Central Coast Height Modernization 2007–8 | CSRC/Towill | 2007.9055–2008.0615 |
| Sonoma County 2008 | UC Riverside | 2008.6598–2008.6680 |
| Sonoma County 2009 | UC Riverside | 2009.5685–2009.5904 |
| The Geysers 2009 | UC Riverside | 2009.7141–2009.7306 |
| North Bay 2010 | UC Riverside | 2010.5288–2010.5584 |

## Proximity to other geodetic networks

The University of California, Berkeley, oversees the BAVU network around the San Francisco Bay area and the USGS's Pillsbury exists north of Clear Lake. Our network bridges this poorly-surveyed gap and provides a means by which to begin working towards a rigorously combined geodetic solution for the whole of the Bay Area and northern California coast.

Additionally, we are occupying alignment array sites to support the work of Jim Lienkaemper (USGS).

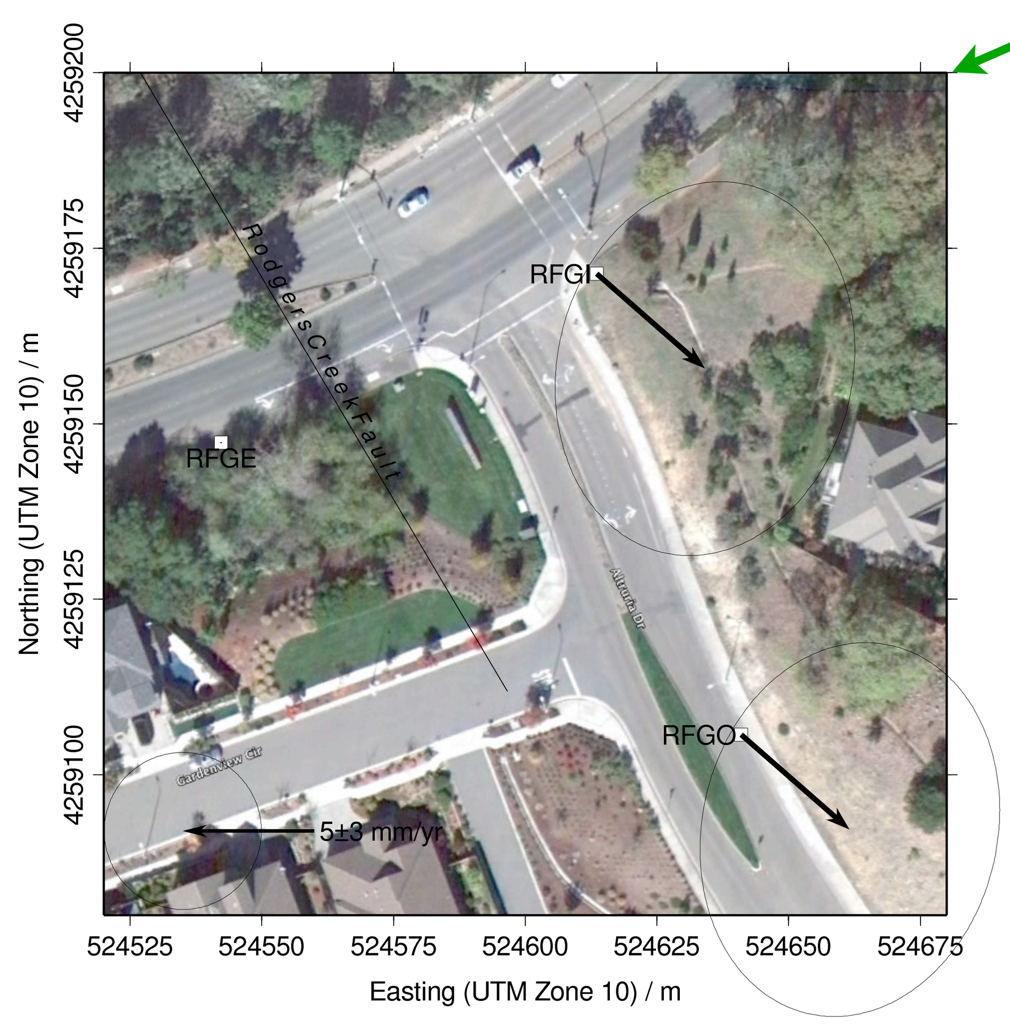


*Figure 2: Zoomed view of current GPS velocities at alignment array 'RCFG' (Rodgers Creek: Fountain Grove Parkway), relative to site RFGE. Though these velocities are based on just one year of data, further measurements may support the existence of surface creep.*

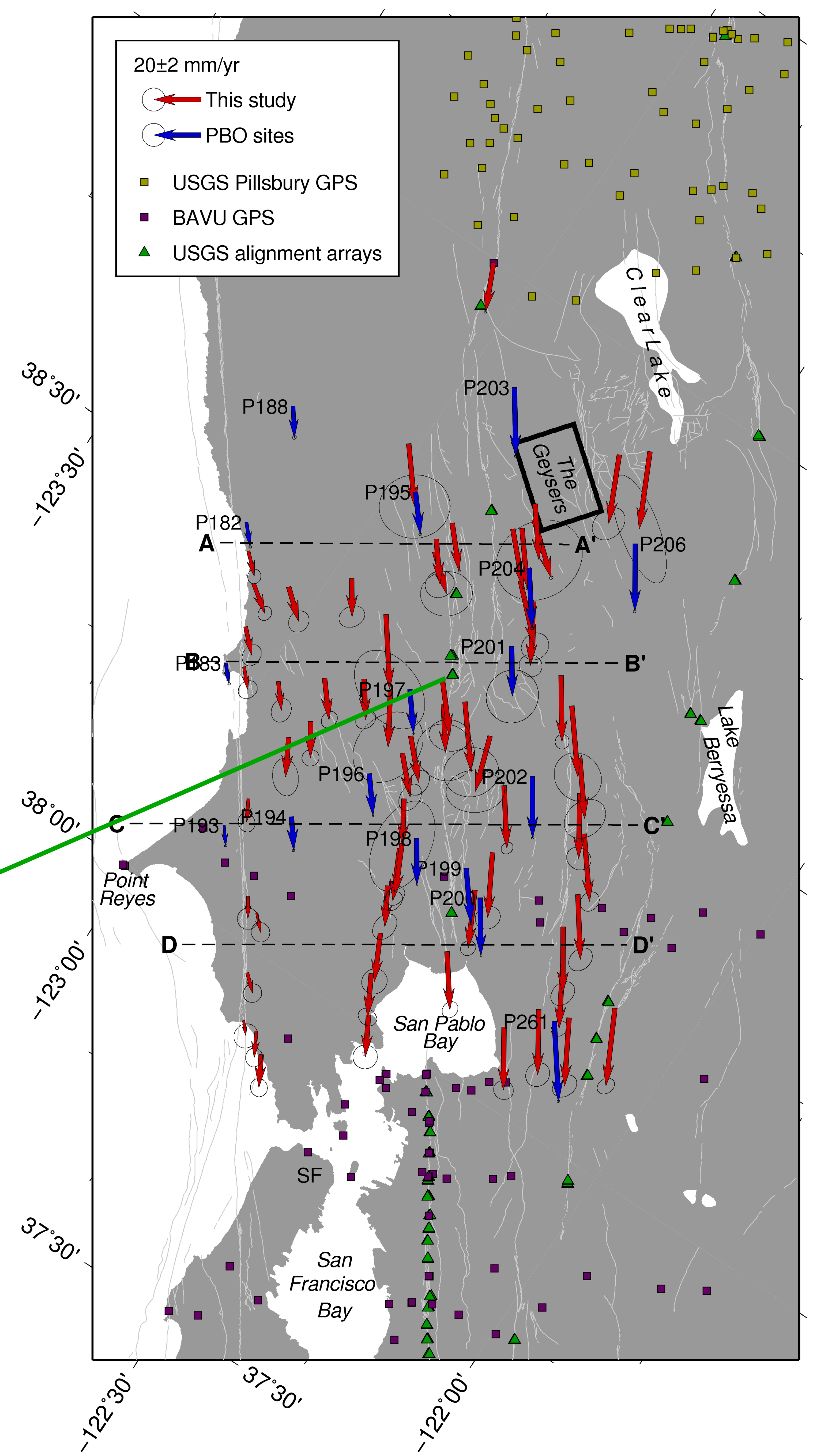


*Figure 1: Velocity solution relative to Pacific plate (ITRF2005, Altamimi et al, 2007). Only sites whose 1-sigma uncertainties are less than 10 mm/yr are shown here. More sites have been occupied, especially near Santa Rosa (intersection of Rodgers Creek Fault and profile B-B'), but currently suffer from a lack of observation period (≤ 2 years).*

## Dislocation modeling and comparison to UCERF2 model

We use a simple elastic model where the dislocation is free to slip but locked above a given depth. This locking depth is fixed to that given in the UCERF2 model for this purpose here. The slip rate is then solved for on three fault systems, which are considered contiguous below the locking depth: the San Andreas, Maacama-Rodgers Creek-Hayward, and Green Valley systems.

An extended model allows each finite fault segment, except the Hayward fault which is not covered by data, to have surface creep constantly above the locking depth. As is seen in Table 2, the current data do not require surface creep to any significant level and the required fault slip rates are changed very little.

Both models are not weighted according to the data because the velocity uncertainties, as well as the velocities themselves, are yet to be rigorously determined. The root-mean-square misfit of both models is 2.6 mm/yr for the 84 sites used north of San Pablo Bay.

| | UCERF2 model | | | Our model | Our model with creep | |
|---|---|---|---|---|---|---|
| Fault | Slip rate mm/yr | Aseismic slip mm/yr | Locking depth km | Slip rate mm/yr | Slip rate mm/yr | Creep rate mm/yr |
| San Andreas (North Coast) | 24 ± 3 | 0 | 11 | 17.1 | 17.5 | 1.2 |
| Rodgers Creek | 9 ± 2 | 0 | 12 | 13.7 | 13.0 | 0.0 |
| Maacama | 9 ± 2 | 3.6 | 12 | 13.7 | 13.0 | 0.0 |
| Green Valley | 5 ± 3 | 2.5 | 14 | 5.2 | 5.8 | 0.0 |
| Hayward (Northern) | 9 ± 2 | 0 | 12 | 13.7 | 13.0 | - |

*Table 2: Results from UCERF2 and our elastic dislocation modeling.*

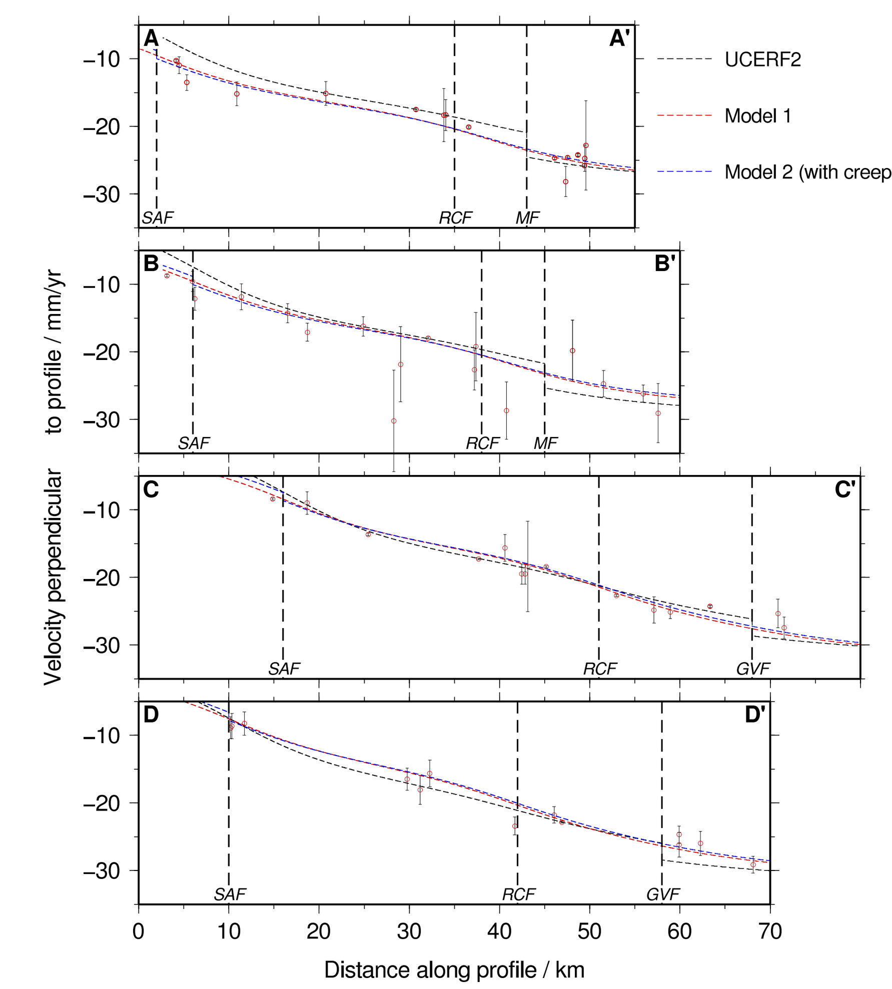


*Figure 3: Profiles through data and models as shown in Figure 1.*

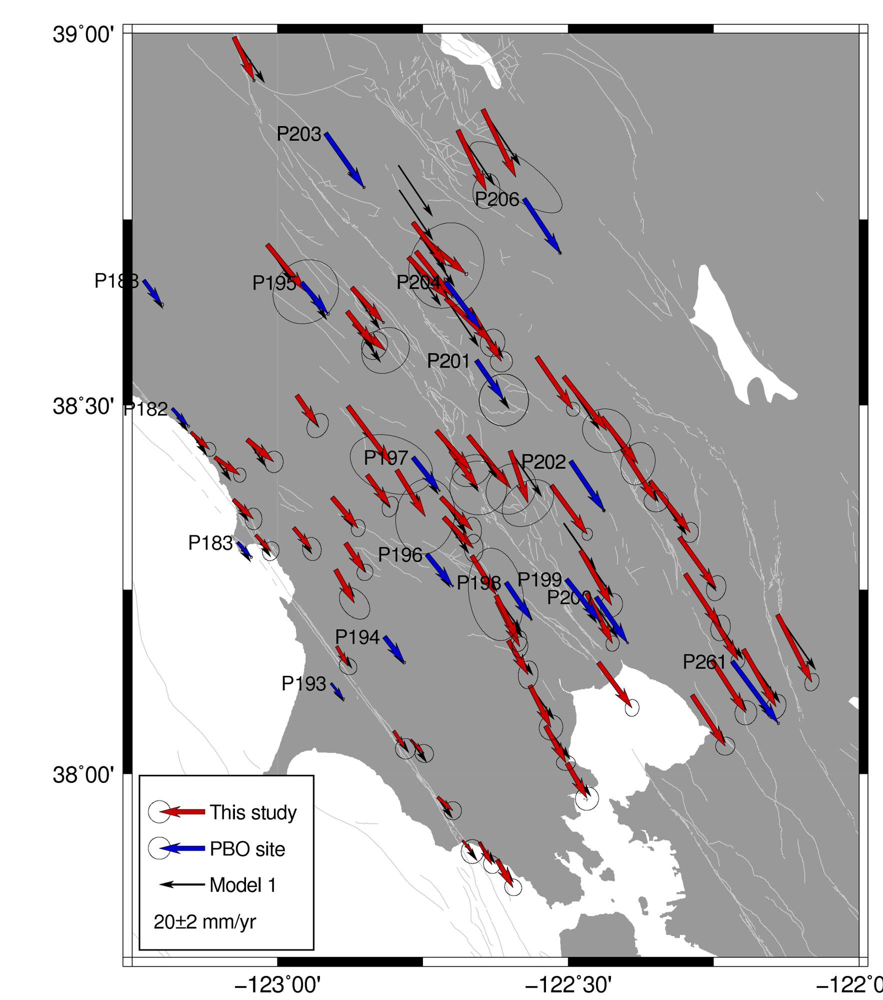


*Figure 4: Comparison of data and model velocities, relative to the Pacific (ITRF2005), for sites used for the solution.*

## Conclusions

As of the time of this presentation, the velocity solution is only a few weeks old. More time and better analysis will reveal characteristics and intricacies of the fault slip rates in the North Bay area.

Our simple model of slip on a deep dislocation yields estimates of slip rate that prefer a higher slip rate on the Maacama-Rodgers Creek-Hayward Fault system and less on the San Andreas Fault compared to the current UCERF2 model and associated hazard predictions. Shallow creep is still to be more rigorously and realistically modeled.

Future work will include better analysis of noise characteristics of more realistic velocity uncertainties, integration of available PBO GPS solutions and other continuous GPS solutions, and combination with ALOS and/or persistent scatterer InSAR.

## References

Altamimi, Z., X. Collilieux, J. Legrand, B. Garayt, and C. Boucher (2007), ITRF2005: A new release of the International Terrestrial Reference Frame based on time series of station positions and Earth Orientation Parameters, *J. Geophys. Res.*, 112, B09401, doi:10.1029/2007JB004949.
Wills, A. J., R. J. Weldon II, W. A Bryant (2008), Appendix A: California Fault Parameters for the National Seismic Hazard Maps and Working Group on California Earthquake Probablities 2007, *USGS Open File Report 2007-1437A*, http://pubs.usgs.gov/of/2007/1437/a/of2007-1437a.pdf.