2011 Annual SCEC report

Collaborative research: Space geodetic investigations of postseismic deformation due to the 2010 El Mayor-Cucapah (Mexico) earthquake

Publications and abstracts resulted from this project:

A. Gonzalez Ortega, D. Sandwell, Y. Fialko, J. Gonzalez Garcia, J. Fletcher , A. Nava Pichardo, M. Floyd, and B. Lipovsky, El Mayor Cucapah earthquake: Postseismic Deformation from InSAR and GPS observations, Abstract G23A-0845 presented at 2011 Fall Meeting, AGU, San Francisco, Calif., 5-9 Dec.

A. Gonzalez Ortega, D. Sandwell, Y. Fialko, J. Gonzalez Garcia, J. Fletcher , A. Nava Pichardo, M. Floyd, and B. Lipovsky, El Mayor Cucapah earthquake: Postseismic Deformation from InSAR and GPS observations, 2011 SCEC Annual Meeting poster A-046.

Summary of results:

The main purpose of this project was to collect campaign GPS data to document postseismic deformation due to the April 4, 2010, M_w7.2 El Mayor-Cucapah (Mexico) earthquake. We carried out two campaign-mode GPS surveys in the epicentral area of the El Mayor-Cucapah (Mexico) earthquake. The surveys were conducted by teams from SIO (PIs Fialko and Sandwell), UCR (PI Funning), and CICESE, Mexico (Alejandro and Javier Gonzalez). The surveys were conducted in April and November of 2011. We occupied 16 monuments within one rupture length of the epicenter that were surveyed within hours and days following the mainshock. Continuous GPS coverage is reasonably good North of the US-Mexico border, but very poor to the South, so campaign GPS measurements are crucial for characterizing the postseismic deformation. Figure 1 shows the locations of the surveyed monuments (blue stars). During each campaign, each site was occupied for at least 2 days; some sites were occupied for more than 10 days. Such a "semi-permanent" occupation mode proved to be very efficient in mitigating propagation effects (e.g., noise due to variable atmospheric moisture).

We also began analysis of the campaign GPS measurements. High-quality data collected in the near field of large shallow earthquakes over the last decade indicate that postseismic relaxation is robust over timescales of several years and is characterized by essentially non-exponential temporal decay (*Barbot et al.*, 2009; *Freed and Bürgmann*, 2004; *Hsu et al.*, 2006; *Johnson et al.*, 2009; *Perfettini and Avouac*, 2004). Our preliminary results reveal a similar behavior in case of the El Mayor-Cucapah earthquake. Figure 2 shows the timeseries of the East component of displacements at site LPUR located within 2 km of the earthquake rupture. Interseismic velocities were subtracted from the signal to isolate the transient. The postseismic displacements in Figure 2 exhibit the log-exponential time dependence typical of afterslip (e.g., *Barbot and Fialko*, 2010; *Barbot et al.*, 2009; *Fialko*, 2004; *Perfettini and Avouac*, 2004). A red line is the preliminary best fit using analytical solutions for a time-dependent response of the rate-state fault to the coseismic stress change (*Barbot et al.*, 2009). As one can see from Figure 2, this model appears to be in a reasonable agreement with the observed postseismic velocities. Data shown in Figure 2 indicate that the postseismic transient will continue for at least several years before the velocities return to preseismic levels. As in recent years the focus has shifted from kinematic inversions for an arbitrary distribution of fault slip to

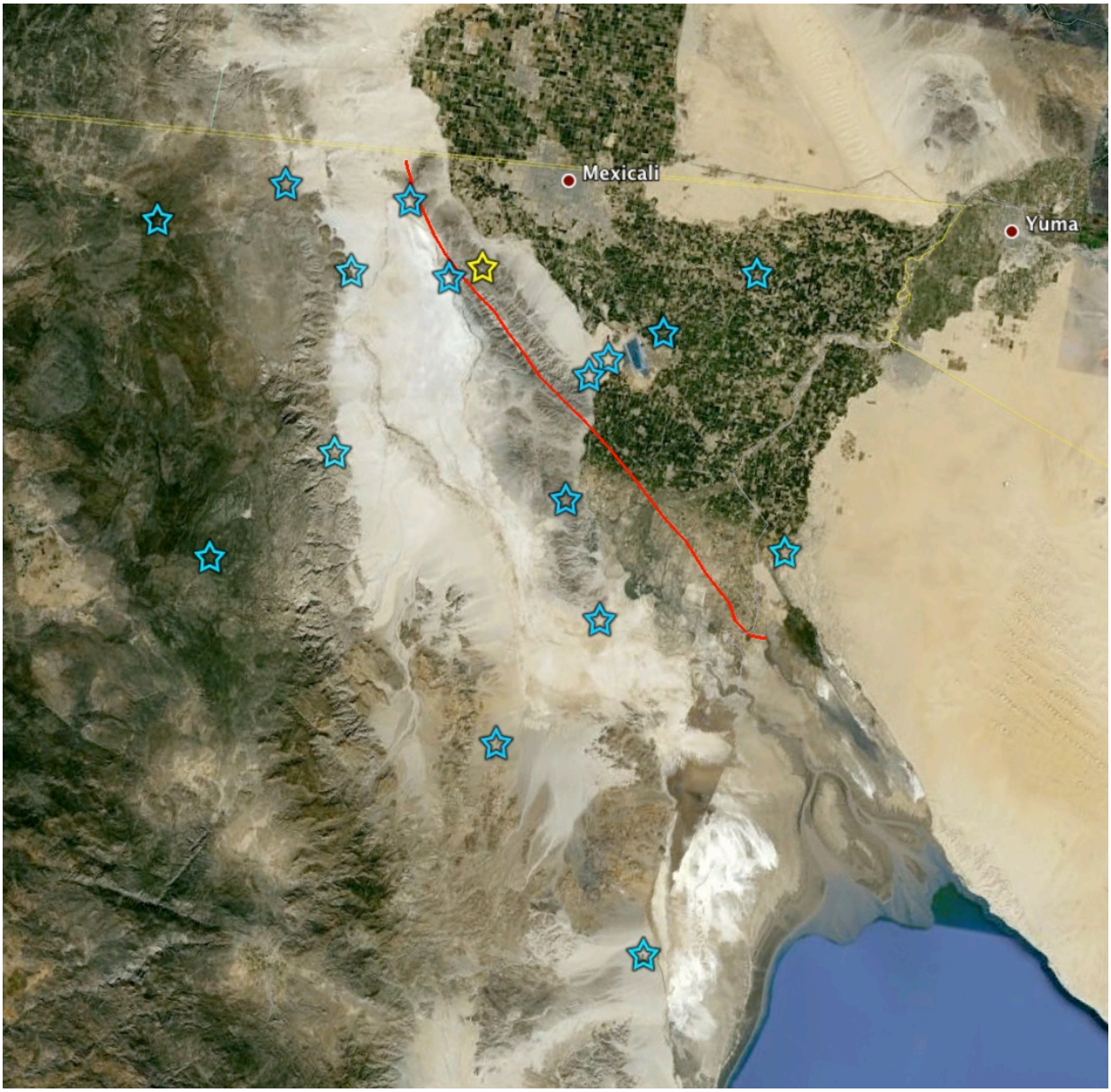

Figure 1: Google Earth map of the epicentral area of the M_w7.2 El Mayor-Cucapah (Mexico) earthquake. The El Mayor-Cucapah rupture is denoted by a red line. Blue stars show the location of campaign GPS benchmarks surveyed in 2011. Yellow star denotes a newly installed permanent GPS site PHJX (Nov. 2011).

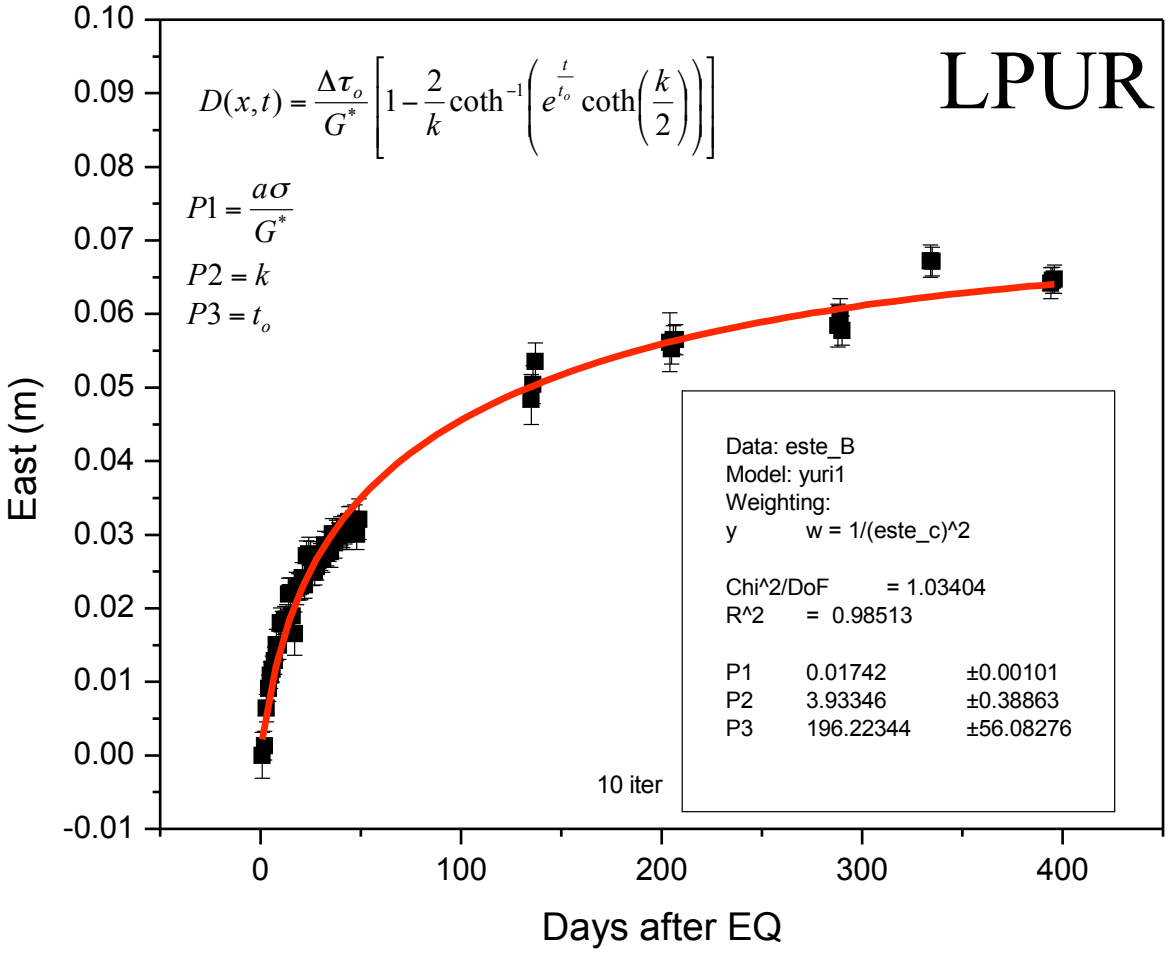

Figure 2: Time series of postseismic displacements from the near-field site LPUR (East component of the displacement vector, black squares). Red line denotes the earthquake date. Data were processed by Alejandro Gonzalez at CICESE. Red line denote the best-fitting "impulse response" assuming rate-and-state rheology and velocity-strengthening friction in the shallow crust (*Barbot and Fialko*, 2010; *Barbot et al.*, 2009).

Figure 3: Continuous GPS site PHJX installed by UNAVCO in support of our investigation of postseismic deformation due to the El Mayor-Cucapah earthquake (see yellow star in Figure 1).

physically-based models of afterslip in which the latter is driven by coseismic stress changes on a fault plane (thereby preventing excessive slip in areas that didn't experience much loading by an earthquake), in subsequent work we will use deformation data such as that shown in Figure 2, and a finite slip model derived from inversions of coseismic deformation data to put better constraints on constitutive behavior of the slip interface, as well as the ambient crustal rocks. A discrimination (or some assessment of the relative importance) of the competing theoretical models is essential for our understanding of mechanical behavior of the lithosphere. In particular, identifying a dominant mechanism of postseismic deformation might help forecast the evolution of stress following large earthquakes, and provide a useful input for seismic hazard estimates.

Also relevant to this project, we leveraged NSF funding to add a permanent continuously recording GPS site next to the earthquake rupture and in the middle of our network of campaign benchmarks (Figure 3). The continuous GPS site PHJX was installed by UNAVCO crews led by Chris Walls in November of 2011, and is now integrated in the PBO network. In addition to providing accurate positioning data with high temporal resolution, this site will help in our future campaign GPS surveys.

This project provided training and support for several graduate students, who participated in all aspects of the field work, instrument deployment, data processing, and preliminary data analysis. It also enabled collaboration between researchers from the US and Mexico.

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