SUPPLEMENTAL INFORMATION

MOMENT TENSOR SOLUTIONS

Earthquake records were acquired from the Northern California Earthquake Data Center. Waveforms are corrected for instrument response, integrated to displacement, rotated to transverse and radial components, bandpassed between 20 and 50 seconds, and finally resampled to 1 sample per second. Moment tensor inversion was performed using the TDMT_INV program of Dreger (2003). Green's functions were generated using the GIL7 velocity model tabulated in Pasyanos et al. (1996). The best fitting moment tensor solutions for the M_w 4.4, M_w 4.0, and M_w 4.8 events are shown in Figures DR1-DR3 below.

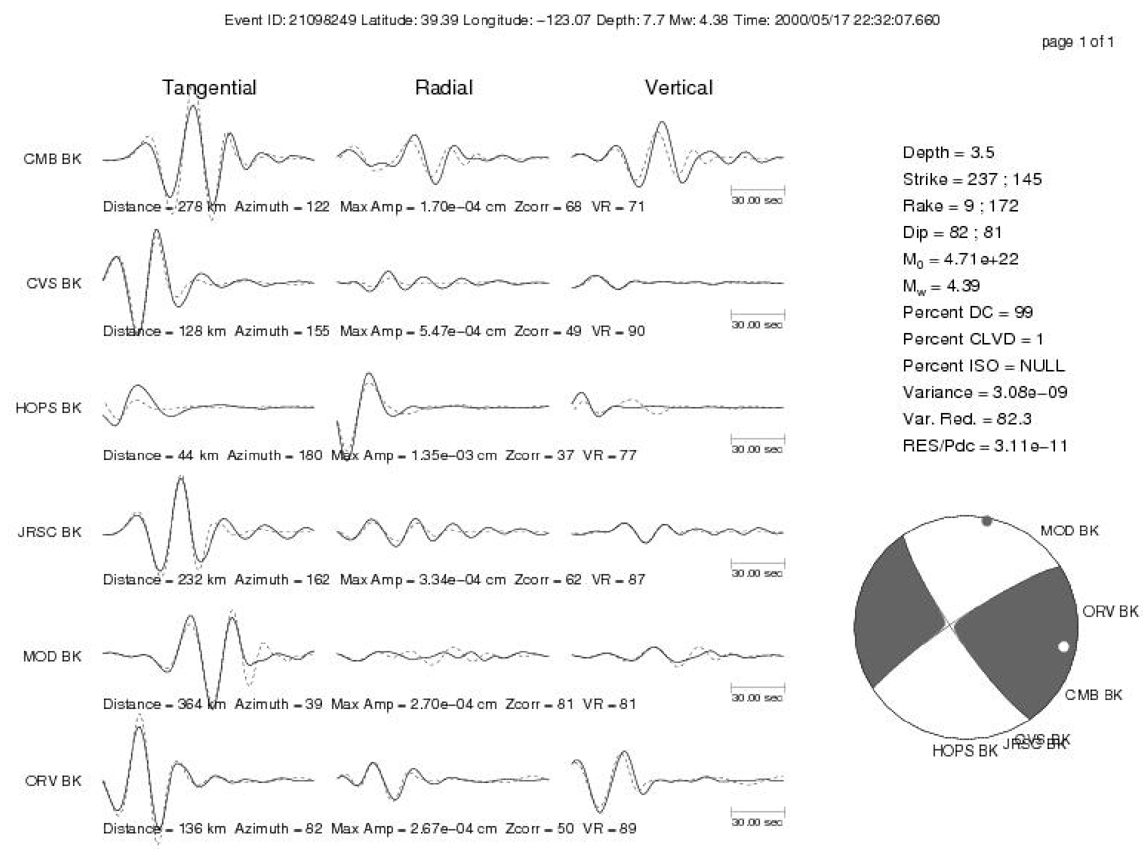


Figure DR1: Best-fitting moment tensor solution for the M_w 4.4 event on May 17, 2000.

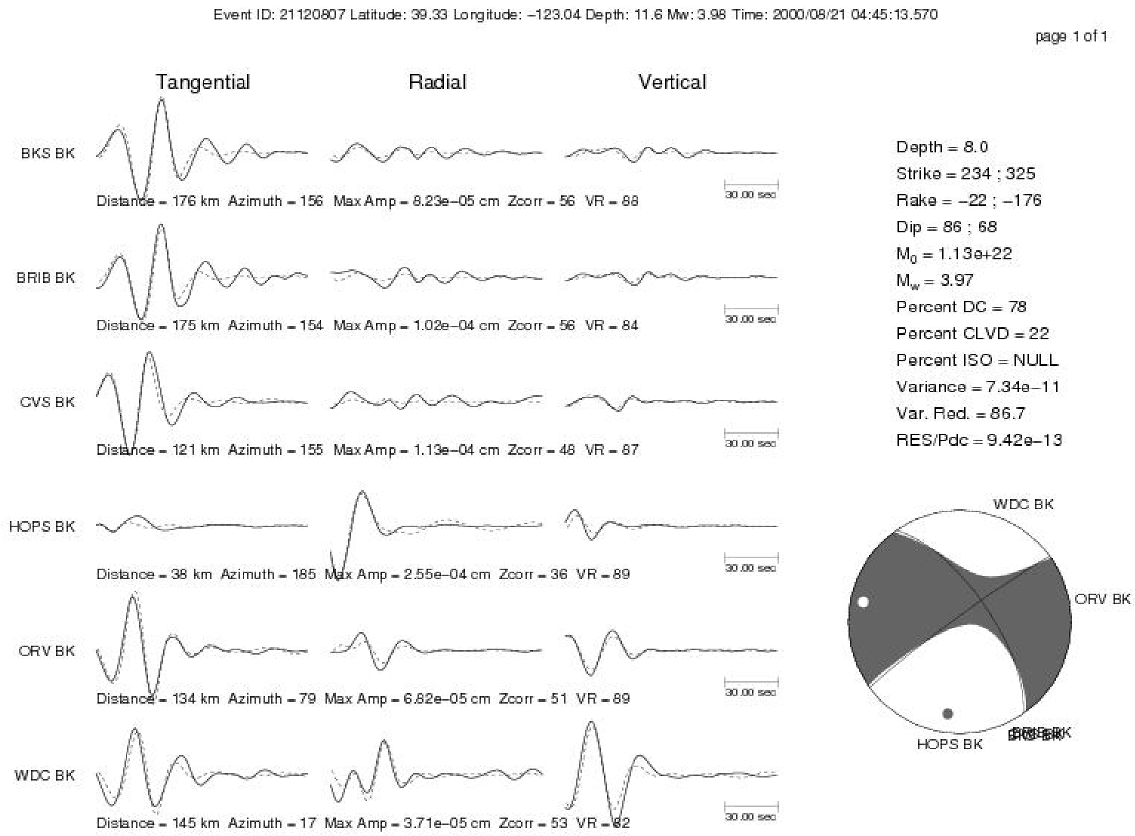
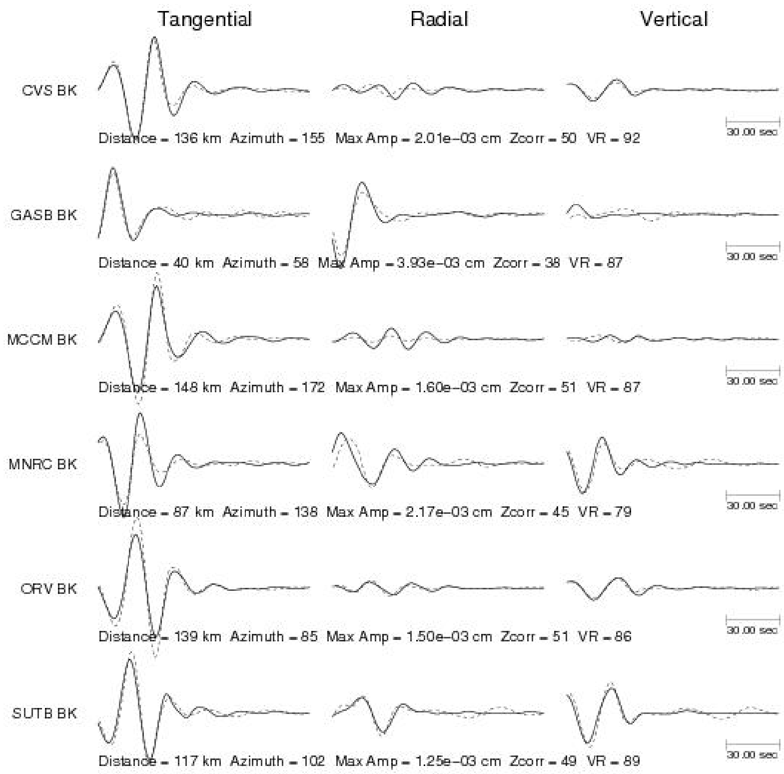
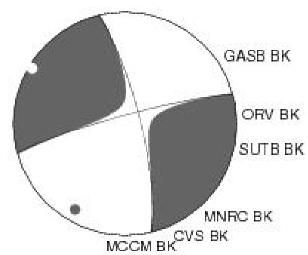


Figure DR2: Best-fitting moment tensor solution for the M_w 4.0 event on August 21, 2000.

Event ID: 40195779 Latitude: 39.46 Longitude: −123.11 Depth: 5.6 Mw: 4.78 Time: 2007/04/18 08:42:22.330



Depth = 3.5
Strike = 255 ; 346
Rake = −11 ; −174
Dip = 84 ; 79
M_0 = 1.87e+23
M_w = 4.79
Percent DC = 91
Percent CLVD = 9
Percent ISO = NULL
Variance = 3.82e−08
Var. Red. = 85.7
RES/Pdc = 4.20e−10



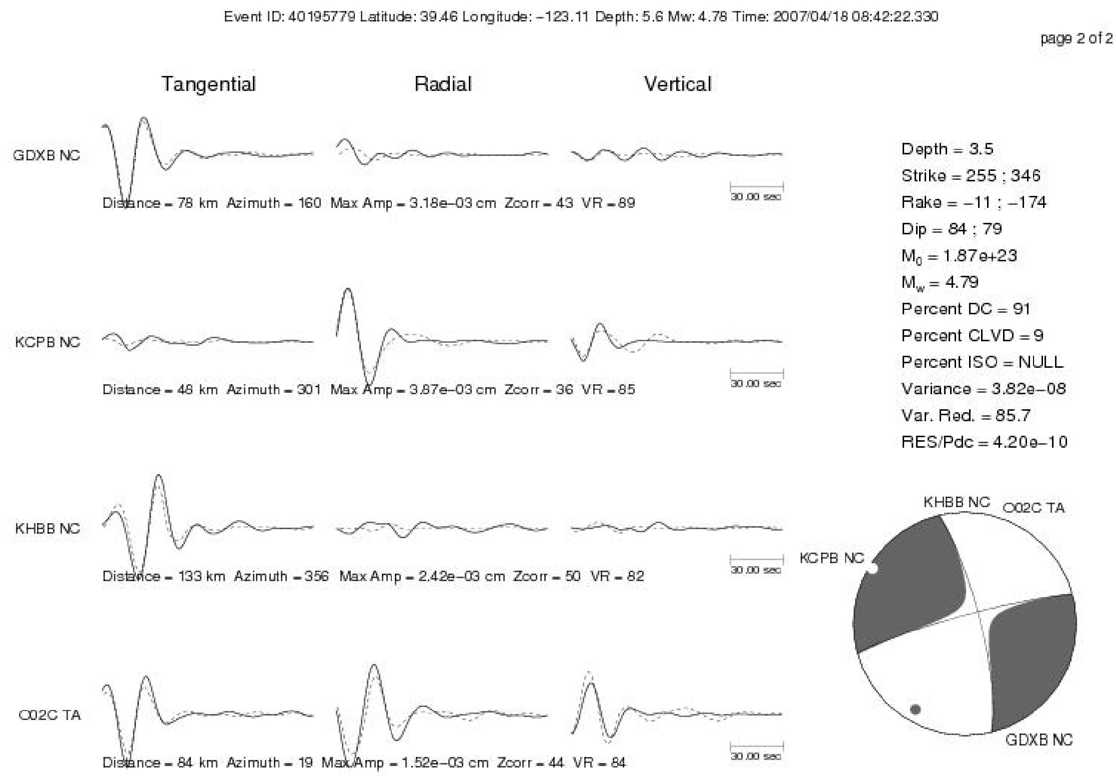


Figure DR3: Best-fitting moment tensor solution for the M_w 4.8 event on April 18, 2007.

Uncertainties in strike, rake, and dip for the three events are shown in Table DR1. These values were determined by computing the event moment tensor solution for every possible combination of stations used in the original solution (Templeton, 2006). These solutions are used to generate distributions of strike and dip values from which the 90% (5^{th} and 95^{th} percentile) and 80% (10^{th} and 90^{th} percentile) confidence intervals quoted in the manuscript are taken.

Table DR1. Averages and uncertainties of the strike and dip of each nodal plane for the M_w 4.4, M_w 4.0 and M_w 4.8 events.

Mw 4.4 Event 21098249											
Nodal Plane 1						Nodal Plane 2					
Strike	46	52	56	60	63	Strike	139	142	145	148	148
Dip	93	95	100	106	110	Dip	84	89	97	105	108
Mw 4.0 Event 21120807											
Nodal Plane 1						Nodal Plane 2					
Strike	52	53	55	59	62	Strike	142	143	145	148	149
Dip	82	83	92	100	102	Dip	53	57	69	77	78
Mw 4.8 Event 40195779											
Nodal Plane 1						Nodal Plane 2					
Strike	71	72	75	77	78	Strike	163	164	166	168	169
Dip	89	91	96	102	104	Dip	69	72	79	88	91

Dark grey corresponds to the 5th and 95th percentile (90% confidence interval) and light grey corresponds to the 10th and 90th percentiles (80% confidence intervals). Dips were defined to be in the east direction so dips of greater than 90° are west dipping planes. For example a N-S striking fault with a dip of 100° actually dips 80°W. This construction was used to generate confidence intervals for near-vertically dipping planes.

Additionally, moment tensor solutions for all three events are not purely double-couple and involve a CLVD component. To test the significance of the non-double couple components we perform Network Sensitivity Solutions using the method of Ford et al. (2010). The results of this analysis indicate that the CLVD components of all three events are insignificant.

FIRST MOTION MECHANISMS

First motion focal mechanisms were computed using HASH (Hardebeck and Shearer, 2002, Hardebeck and Shearer, 2003). We used six candidate velocity models for northern California which are tabulated in the USGS open-file report on the Northern California Seismic Network (Oppenheimer et al., 1993). The BAE, BAR, MAA, and MAN models derive from the study of Castillo and Ellsworth (1993), NCG is a model that was not published outside the Open File Report, and the GIL7 model is tabulated in Pasayanos et al. (1996). Focal mechanisms were computed for events greater than magnitude 2 with 25 or more first motion observations. S/P amplitude ratios were not included in focal mechanism determination. First motion solutions generally have large uncertainties in strike, rake, and dip, which are primarily due to gaps in the takeoff angles. The majority of fault plane solutions are quality D meaning they have a maximum azimuthal gap of ≤ 90°and a maximum takeoff angle gap ≤ 60°. RMS fault plane uncertainties are generally large with an average value of 44°. However, the similarity of nearby first motion solutions and agreement with the independent analyses of McLaren et al. (2007) and Hayes et al. (2006) suggests that solutions may be useful in constraining lineament geometry. It is also worth noting that station coverage improved drastically between 2000 and 2007 with the installation of the Transportable Array stations in the area which lends support for the heterogeneity of mechanisms in the north that took place as part of the later, 2006-7 swarm. Stacks of all focal mechanism solutions for S1 and S2 are shown in Figure DR4 below.

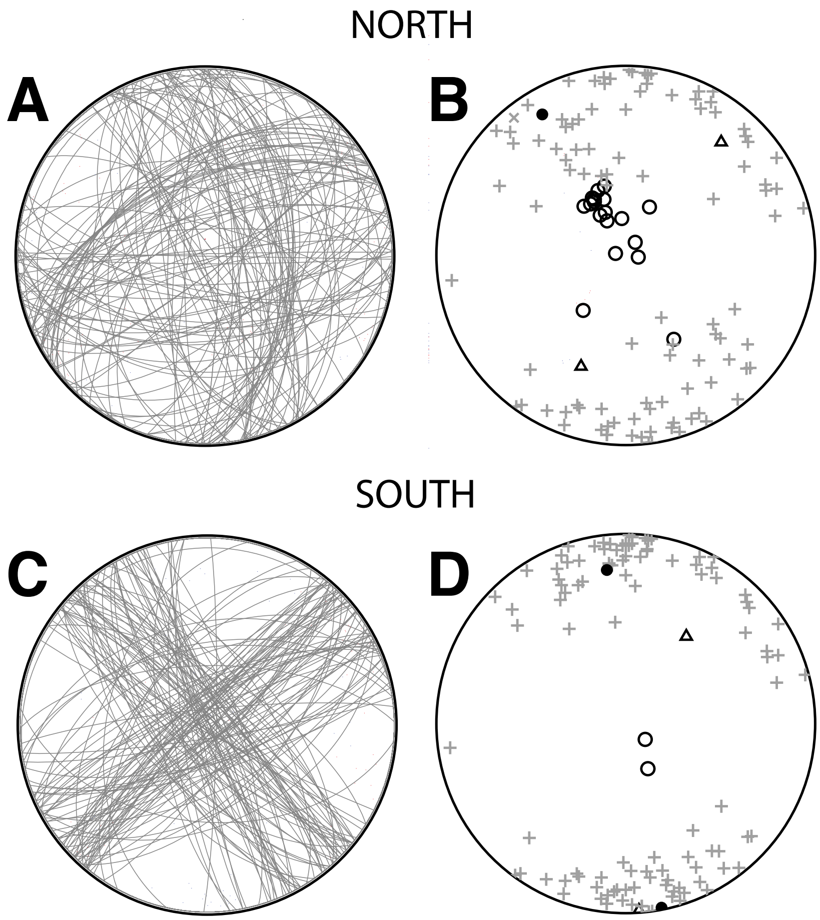


Figure DR4: A and C show focal mechanism solutions for all events. B and D show the trend and plunge of *p*-axes for focal mechanisms. Gray crosses are strike-slip events, open black circles are normal events, and black triangles are thrust events. Filled black circles are *p*-axes for the three moment tensor solutions.

b-VALUES

We estimate b using the maximum likelihood method of Aki (1965) and Utsu (1965) where

$$b = \log e / (M - M_c)$$

Here M is the average magnitude of a population of events and M_c is the minimum magnitude of the events considered or the magnitude of completeness (here M_c=2.0). To avoid many of the common errors in *b*-value estimation, we use only local magnitudes for consistency. We compute uncertainties in estimated *b*-values as a function of population size using bootstrap sampling from an exponential distribution with *b*=1.

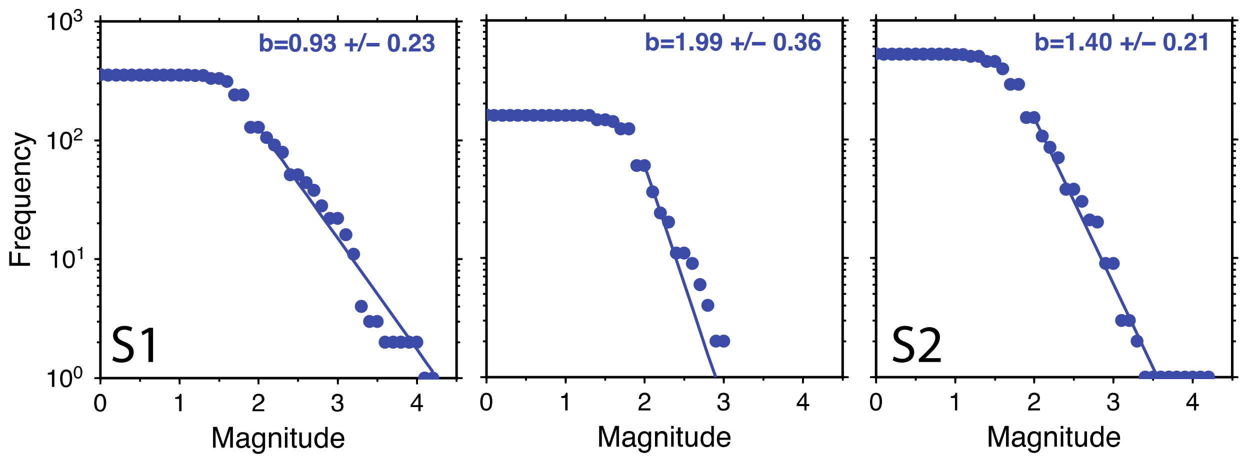


Figure DR5: *b*-value distributions for the 2000 swarm (S1), time period between swarms (2001-2006.5), and the 2006-2007 swarm (S2). Maximum likelihood estimates for *b* plus uncertainties are shown in blue in the top right of each of the top panels.

DIFFUSION CURVES

The diffusion envelopes in Figures 3E and 3F were made following the approach of Malagnini et al. (2012) for 1-dimensional diffusion. Diffusion curves were generated from equation 9 in Malagnini et al. (2012)

where d is distance, D is the diffusivity, and t is time. For Figures 3E and 3F, we eliminated the 2.32 (which is a factor derived from $d = 2.32\sqrt{Dt}$ an arbitrary choice of boundary layer thickness).

REFERENCES

Aki, K., 1965, Maximum Likelihood Estimate of b in the Formula logN= a-bM and its Confidence Limits. Bull. Earthquake Res. Inst., Tokyo Univ. 43, 237-239.

Castillo, D. A., and Ellsworth,W. L., 1993, Seismotectonics of the San Andreas fault system between Point Arena and Cape Mendocino in northern California: Implication for the development and evolution of a young transform: Journal of Geophysical Research, v. 98, p. 6543–6560.

Dreger, D. S., 2003, TDMT_INV: Time Domain Seismic Moment Tensor INVersion: International Handbook of Earthquake and Engineering Seismology, v. 81B, p. 1627.

Ford, S. R., Dreger, D. S., and Walter, W. R., 2010, Network Sensitivity Solutions for Regional Moment-Tensor Inversions: Bulletin of the Seismological Society of America, v. 100, p. 1962–1970, doi: 10.1785/0120090140.

Malagnini, L., Lucente, F. P., De Gori, P., Akinci, A., & Munafo, I. (2012). Control of pore fluid pressure diffusion on fault failure mode: Insights from the 2009 L'Aquila seismic sequence. *Journal of Geophysical Research: Solid Earth (1978–2012)*, *117*(B5).

Minson, S. E., and Dreger, D. S., 2008, Stable inversions for complete moment tensors: Geophysical Journal International, v. 174, p. 585-92.

Oppenheimer, D., Klein, F., Eaton, J., and Lester, F., 1993, The Northern California Seismic Network Bulletin January - December 1992: U.S. Geological Survey Open-File Report 93-578.

Pasyanos, M., Dreger, D. S., and Romanowicz, B., 1996, Toward real-time estimation of regional moment tensors: Bulletin of the Seismological Society of America, v. 86, p. 1255-1269.

Templeton, D. C., and Dreger, D. S., 2006, Non-Double-Couple Earthquakes in the Long Valley Volcanic Region: Bulletin of the Seismological Society of America, v. 96, p. 69-79.

Utsu, T., 1965, A method for determining the value of b in formula log N = a - bM showing the magnitude-frequency relation for earthquakes, Geophys. Bull. Hokkaido Univ. 13, 99-103.