SUPPLEMENTAL MATERIAL

Ometepec Earthquake Hypocenter - A global network was used to determine the original USGS location, which placed the earthquake hypocenter near the downdip portion of the seismogenic zone. However, analysis of P-wave arrivals from our local network determined the hypocenter to be further updip and away from the SSE. P-waves arrive first at stations OXMA and PNIG, while arrivals at the next nearby locations OXTT, OXTL, and TLIG occur over 8 seconds later. This updated location is similar to another analysis of regional data (*UNAM Seismology Group*, 2013).

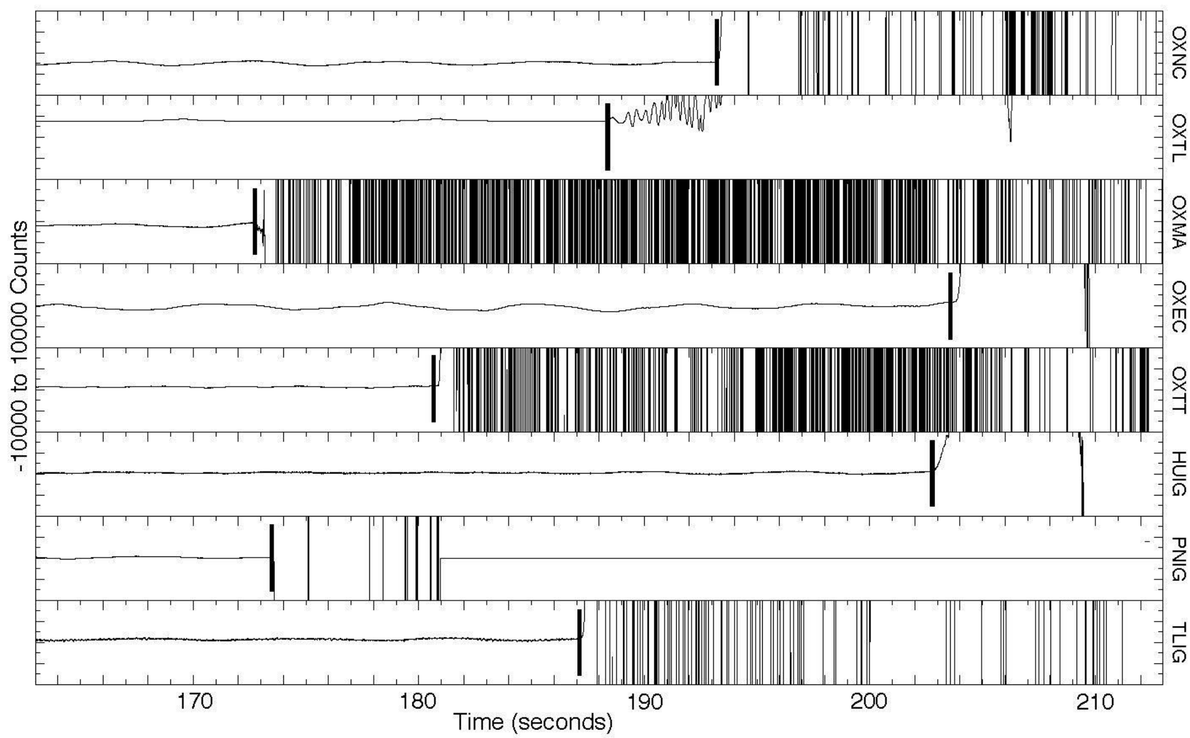

Figure S1. Seismograms of the Mw 7.4 Ometepec earthquake showing relative time of first arrivals on the vertical channel. Vertical axis is set at 10,000 counts to best view first motions. Note that many of these weak motion instruments clipped.

***Distinguishing Earthquakes and Cultural Noise from Tremor* -** This study uses a frequency scanning detection algorithm developed for Cascadia to seismic data from the local network in the Oaxaca region to exploit the unique frequency content of tectonic tremor (2-5 Hz). Figure S2 illustrates evidence that this technique avoids possible false detections from cultural noise and local earthquakes.

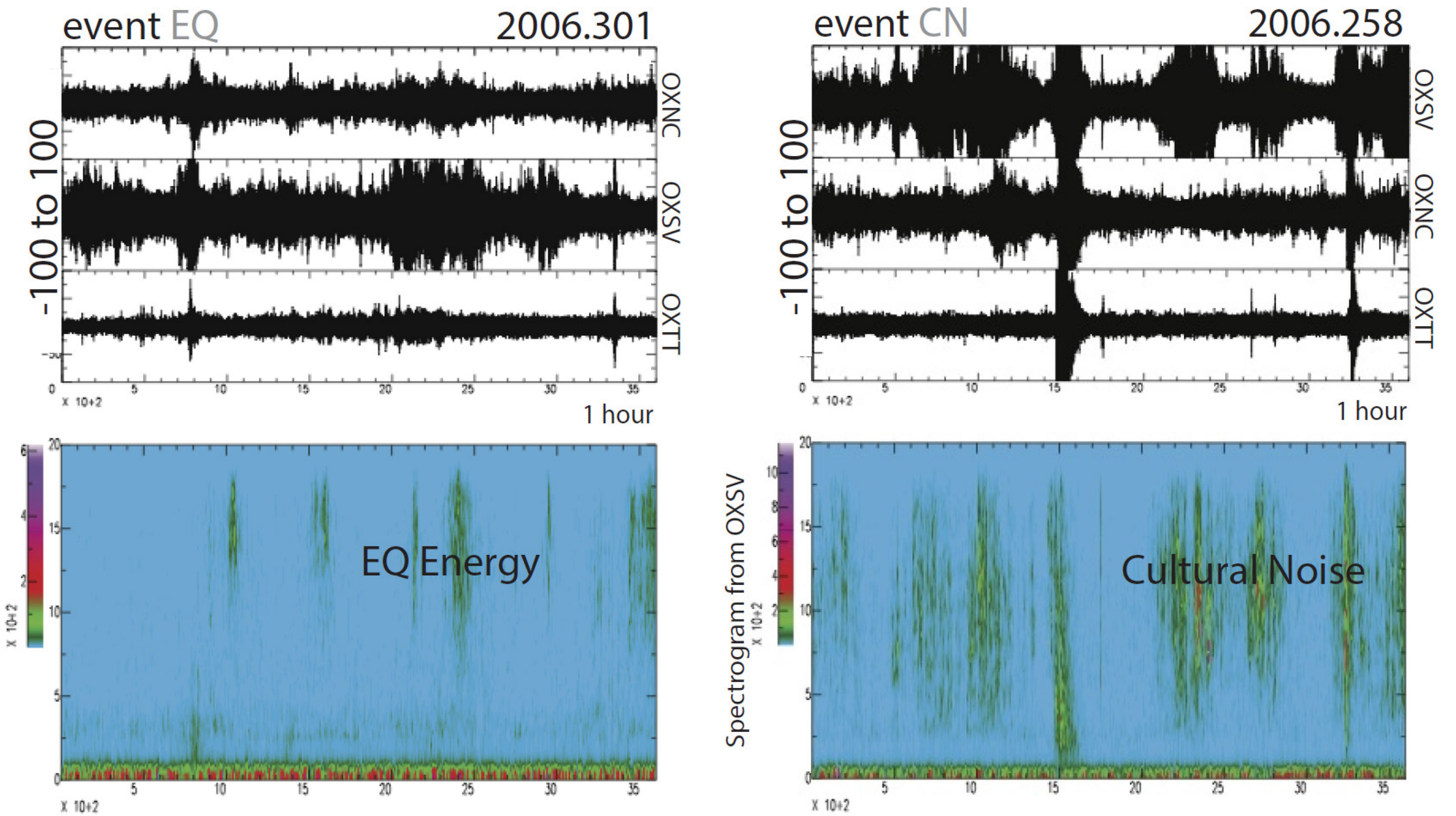

Figure S2. Examples of correlated activity (left) earthquake energy and (right) cultural noise distinguished with help from spectral analysis. Top panels show bandpass (2-5 Hz) filtered seismograms from nearby stations exhibiting non-tremor seismic signals. Bottom panels show spectrograms of unfiltered data with bursts of energy focused above the typical tremor frequency band.

Tremor Epicenters Relative to Slow Slip and Earthquakes – To help illustrate more detail regarding the relationship between the various forms of seismic and slip behavior, Figure S3 shows the locations of tectonic tremor epicenters cataloged by *Fasola et al.* (2016), instead of the contour outlining the distribution of tremor in Figure 1.

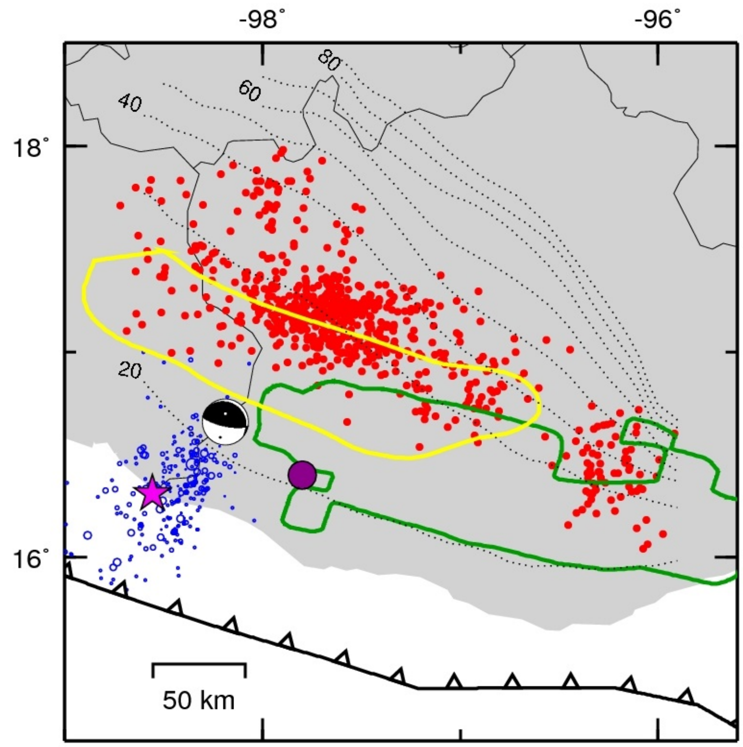

Figure S3. Map showing the various forms of seismic and slip behavior, and the slab depth contours (dotted lines) (*Fasola et al.*, 2016). This figure is the same as Figure 1, but shows the tectonic tremor epicenters as red circles (*Fasola et al.*, 2016).

Table S1. List of observations of transient deformation prior to earthquakes.

Earthquake	Observation	Start Time	Equivalent Moment Magnitude of Pre-Earthquake Slip	References
1. Primarily Geodetic Observations of Transient Deformation Before Large Earthquakes				
M9 Cascadia, USA and Canada; January 29, 1700	Microfossils	Unknown	Unknown	*Shennan et al*. 1998
Ms8.2 Tonankai, Japan; December 7,1944	Leveling	1 day	7.8	*Sagiya* 1998, *Linde and Sacks*, 2002
Mw8.3 Nankaido, Japan; December 20,1946	Tide Gauges, Water wells	3 days	7.9	*Sato*, 1982, *Linde and Sacks,* 2002
Mw9.2 Chile May 22, 1960	Long-period seismometer	14-20 min	8.9-9.1	*Cifuentes & Silver,* 1989
Mw9.2 Prince William Sound, AK, March 28, 1964	Microfossils	10-12 years	.12 m +/- .13 m uplift	*Hamilton and Shennan,* 2005
M7.0 Izu-Oshima-Kinkai, Japan; January 14,1978	Leveling, groundwater levels, geodolite, tide gauges	2 years	15 cm uplift	*Inouchi and Sato*, 1979, *Wakita,* 1981
Ms 6.8 Urakawa-oki, Japan; March 21, 1982	Leveling, groundwater levels, geodolite, tide gauges	3-11.5 years	.4 m sllip	*Taylor et al.* 1991; *Iio et al.,* 2002; *Murai et al.,* 2003
Ms 7.8 Japan Sea; May 26, 1983	Tide gauges, borehole strain	14 years	7.7	*Iio et al.,* 2002, *Mogi,* 1985
Mw 6.1 Kettleman HIlls, CA; August 4,1985	borehole strain, water levels	3 days	5.4	*Roeloffs and Quilty*, 1997
Mw 7.6 Peru; July 7, 2001	CGPS	18 h	7.8	*Melbourne & Webb,* 2002
Mw 9.0 in 2011 Tohoku, Japan	Pressure gauge + EQ Swarm migrating along strike	40 days	7	*Ito et al*., 2013; *Miyazaki et al.*, 2011
Mw 6.3 in 2009 in L'Aquila, Italy	GPS contrained SSE - 2 week duration	About 6 weeks	Mw 5.9	*Borghi et al.*, 2016
Mw 8.1 in 2014 Iquique, Chile	GPS detected	About 2 weeks	slip of 5 mm-1cm	*Ruiz et al.,* 2014
2. Earthquake Swarms As Indicators of Transient Deformation Before Large Earthquakes				
Mj 7.1 in 1989 in Sanriku, NE Japan	Local earthquakes including 4 M6 events representing quasi-static slip acceleartion	6 days	greatest slip patch ~10 cm	*Uchida et al.,* 2004
Mj 6.9 in 1992 in Sanriku, NE Japan	Local earthquakes representing quasi-static slip acceleartion	2 days	greatest slip patch ~10 cm	*Uchida et al.,* 2004
Mj 7.6 in 1994 in Sanriku, NE Japan	Local earthquakes representing quasi-static slip acceleartion	8 months	greatest slip patch ~10 cm	*Uchida et al.,* 2004
M>5 from 1985 - 2012 in Sanriku, NE Japan	Repeating earthquakes			*Uchida et al.,* 2016
Mw 7.6 Izmit,Turkey	40 event swarm; Templates M.3-2.7	44 min	largest foreshock - slip patch of 0.8 cm	*Bouchon et al.*, 2011
M 6.0 Parkfield, CA	Deep LFE - increase in LFE rate by 47%	3 months	<3.2	*Shelly,* 2009
Mw 9.0 in 2011 Tohoku, Japan	Eq Swarm - 1416 events, more than 4 times original JMA catalogue; Migration observed 2-10 km/day	23 days	~7.1 (~20 cm slip)	*Kato et al.,* 2012
Mw 7.6 in 2012 Nicoya, Costa Rica	Mw7.3 El Salvador EQ 9 days before triggered swarm (M1-2); Mainshock preceded by swarm	9 days before; 35 minute before	none reported	*Walter et al.,* 2015
Mw 8.1 in 2014 Iquique, Chile	earthquake swarm (>M4), 10 times normal amount, migrations 2-10km/d	About 2 weeks	none reported	*Kato and Nakagawa,* 2014; *Brodsky and Lay,* 2014
Mw 6.3 in 2009 in L'Aquila, Italy	Local earthquakes (M0.4-3.9). Migrating swarm occurs during GPS SSE	About 2.5 months; surge of foreshocks in the week prior	none reported	*Sugan et al.*, 2014

Location	Observed Signals	Duration	Equivalent Moment Magnitude of Slow Slip	References
3. Geodetic Observations of Transient Deformation Correlated with Earthquake Swarms				
Salton Trough, CA - Aug 2005	GPS and INSAR detected aseismic slip combined with a swarm of seismicity 3 orders of magnitude larger than normal observations	35 days	5.75	*Lohman and McGuire,* 2007
Gisbourne - October 2004	GPS constrained slow slip accompanied by increase in low magnitude earthquakes	10-14 days	~18 cm of slip	*Delahaye et al.,* 2009
Ecuador - August 2010	GPS constrained slow slip accompanied by seismic swarm of 650 earthquakes	~10 days	6-6.3	*Vallée et al.,* 2013
Boso Peninsula - Oct 2002	GPS constrained slow slip with accompanying adjacent seismic swarm	About 40 days	6.6	*Ozawa et al.,* 2003
Boso Peninsula - April 1996	GPS constrained slow slip with accompanying adjacent offset seismic swarm	About 2 months	6.4-6.5	*Ozawa et al.*, 2003; *Sagiya,* 2004
Boso Peninsula - August 2007	GPS constrained slow slip with accompanying adjacent seismic swarm	About 10 days	6.6	*Ozawa et al.* 2003
Apennines, Central Italy - March 1997	Slow events recorded by a geodetic interferometer accompanied by a few seismic swarms	A couple months?	4.1?	*Crescentini et al.*, 1999
Guerrero - 1998	GPS constrained slow slip accompanied by an increase in seismicity rate of Mc 4.5 events	About 5 months	6.5	*Liu et al.,* 2007; *Lowry et al.,* 2001
Guerrero -2001-2002	GPS constrained slow slip accompanied by an increase in seismicity rate of Mc 4.5 events	About 7 months	7.5	*Liu et al.,* 2007
Guerrero 2006	GPS constrained slow slip accompanied by an increase in seismicity rate of Mc 4.5 events	About 10 months	7.5	*Liu et al.,* 2007; *Larson et al.,* 2007
San Andreas Fault - December 1992	Week long slow slip event near San Juan Bautista recorded by borehole strain meters with an increase in small (M2-4) seismicity	About a week	4.8	*Linde et al.*, 1996
Cascadia - March 2010	Slight increase in tiny (M<2) earthquakes during slow slip presumed based on tectonic tremor activity that is well correlated to slow slip in Cascadia	About 16 days	none reported	*Vidale et al.*, 2011
Kilauea - February 1998	GPS constrained slow slip with an earthquake ratio increase of 2.75	About 2 days	none reported	*Brooks et al.*, 2006; *Montgomery-Brown et al.*, 2009
Kilauea - September 1998	GPS constrained slow slip with an earthquake ratio increase of 3.1	About 2 days	5.6 (0.05 m slip)	*Segall et al.*, 2006; *Brooks et al.*, 2006; *Montgomery-Brown et al.*, 2009
Kilauea - November 1999	GPS constrained slow slip with an earthquake ratio increase of 4.0	About 2 days	none reported	*Brooks et al.*, 2006; *Montgomery-Brown et al.*, 2009
Kilauea - May 2000	GPS constrained slow slip with an earthquake ratio increase of 7.15	About 2 days	none reported	*Montgomery-Brown et al.*, 2009
Kilauea - November 2000	GPS constrained slow slip with an earthquake ratio increase of 1.8	About 1.5 days	5.7 (0.06 m slip)	*Segall et al.*, 2006; *Brooks et al.*, 2006; *Cervelli et al.,* 2002

Kilauea - December 2002	GPS constrained slow slip with an earthquake ratio increase of 1.1	About 2 days	none reported	*Brooks et al.,* 2006; *Montgomery-Brown et al.*, 2009
Kilauea - July 2003	GPS constrained slow slip with an earthquake ratio increase of 2.75	About 2 days	5.5	*Segall et al.*, 2006; *Brooks et al.*, 2006; *Montgomery-Brown et al.*, 2009
Kilauea - January 2005	GPS constrained slow slip with an earthquake ratio increase of 10.5	About 2.2 days	5.8 (0.15 m slip)	*Segall et al.* 2006; *Brooks et al.*, 2006; *Montgomery-Brown et al.*, 2009

Compendium of Transient Deformation Observations Prior to Earthquakes - As a supplement to the discussion section of our paper, Table S1 represents an effort to compile relevant aspects of other published observations of transient deformation, or seismic swarms that imply transient deformation, prior to earthquakes.

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