Supplementary Material for "Delayed Seismicity Rate Changes Controlled by Static Stress Transfer"

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1. Trivial mixture model example

Here we provide the derivation of a trivial example (mentioned in the introduction of the main manuscript) of the asymmetric effects of a nominal shadow zone that contains a small fraction of sources that received a positive ΔCFS compared to the opposite situation. We will use r for event rates. Subscripts 0 and 1 indicate values immediately before and after the stress step, respectively. Superscripts $+$ and $-$ refer to the populations that received positive and negative stress steps, respectively, with the lack of superscript indicating the total rate (which will be given by the weighted sum of the $+$ and $-$ rates: $r_i = f_p r_i^+ + (1-f_p) r_i^-$). f_p is the fraction of mechanisms that received a positive stress step. We derive results for 5% contamination, thus $f_p = 0.95$ for the nominal triggering case and 0.05 for the nominal shadowing case. Before the stress step, the $+$ and $-$ rates are equal: $r_0^+ = r_0^- = r$, so the total rate is also just r: $r_0 = f_p r_0^+ + (1-f_p) r_0^- = f_p r + (1-f_p) r = r$. We assume a stress step that changes the rates by a factor of 100: $r_1^+ = 100 r_0^+ = 100r$ and $r_1^- = 0.01 r_0^- = 100r$ (in RSF, this would correspond to a $\Delta\text{CFS} = \pm 4.6\, a\sigma$).

Consider first the nominal triggering zone (so $f_p = 0.95$). In the absence of the 5% contamination, the rate after the stress step would have simply been $r_1 = 100r$; the contamination alters this to

$$r_1 = f_p r_1^+ + (1-f_p) r_1^- \tag{1}$$

$$= 0.95(100r) + 0.05(0.01r) \tag{2}$$

$$= 95r + 0.0005r \tag{3}$$

$$\approx 95r. \tag{4}$$

So there is still clear triggering with an amplitude of about 5% less than without the contamination.

For the nominal shadow zone ($f_p = 0.05$) the situation is very different. Without the contamination, the rate after the stress step would have been $r_1 = 0.01r$, but with the contamination we have

$$r_1 = f_p r_1^+ + (1 - f_p) r_1^- \tag{5}$$

$$= 0.05(100r) + 0.95(0.01r) \tag{6}$$

$$= 5r + 0.0095r \tag{7}$$

$$\approx 5r. \tag{8}$$

Thus a mere 5% contamination of a nominally shadowed population changes the overall rate response from a reduction by a factor of 100 to a factor of 5 increase.

Figure S1. (Caption on following page)

Figure S1. (Previous page) ΔCFS from the EMC event in the Yuha Desert for three source models. a) The EMC source is characterized by an average of 2.5 m of right-lateral slip distributed along a planar fault that tapers linearly to the fault edges. Source parameters are within the error of the gCMT moment tensor solution. The strike, dip, and rake reported for the EMC event are 313°, 88°, -174°, respectively. b) EMC source from the finite fault solution from [*Wei et al.*, 2011]. c) EMC source from the finite fault solution from *Mendoza and Hartzell* [2013]. In all panels occurs, seismicity (green) between 4 April and 30 December 2010 from the YHS catalog. The study region used in Figures 2-4 of the main text is outlined by the grey box, and the Regions of interest (I, II, and III) are outlined with the gray dashed lines. These models show that the amplitude of the positive ΔCFS increases for each source fault, moving from panels *a* to *c*. This indicates that the EMC event imparted at least 0.2 and perhaps >4 MPa positive Coulomb stress change across the Yuha Desert. However, *Rymer et al.* [2011] found only triggered surface slip and no evidence of surface rupture due to the mainshock in the Yuha Desert, so the finite fault models in panels *b* and *c* (that incorporate a through-going EMC source fault well into the Yuha Desert), may be over-estimating the amplitude of ΔCFS . Additionally, this will also affect the spatial distribution of the ΔCFS.

Figure S2. (Caption on following page)

Figure S2. (Previous page) Magnitude of completeness for the HYS and YHS catalog (method of *Mignan and Woessner* [2012]) and distribution of event types from the YHS catalog. a) M_c for both the HYS and YHS catalogs as determined by the maximum curvature method [*Mignan and Woessner*, 2012], indicating that M_c =1.6. b) M_c as a function of time since the EMC event for the HYS catalog. c) M_c as a function of time since the EMC event for the YSH catalog. Both the HYS and YHS catalogs are incomplete for $\approx$ 5 days following the EMC event, when the M_c quickly falls to the average value. d) Ternary diagram of focal mechanism solutions for all events in the YHS catalog (regardless of magnitude) plotted in equal area projection based on the method of *Kaverina et al.* [1996] and *Kagan* [2005]. Diagram was made using the FMC code from *Álvarez-Gómez* [2014]. e-g) Distribution of normal, strike-slip, and reverse faulting events, respectively, in the Yuha Desert.

Figure S3. Alternate ΔCFS maps for left-lateral receiver faults (top) and normal receiver faults (bottom). a) ΔCFS map for the most dominant event type (northeast trending left-lateral receiver faults) used when defining the regions of positive and negative ΔCFS due to the Ocotillo event. Receiver fault orientation based on mapped faults that exhibit surface rupture during the EMC event [*Rymer et al.*, 2011]. The dip was inferred from relocated seismcity from [*Kroll et al.*, 2013]. Dashed lines show the outlines off geographical Regions I-III as defined in text. b) Alternate ΔCFS for northeast trending left-lateral receiver faults aligned according to the average northeast trending nodal plane orientation from the YHS catalog. c) ΔCFS map for normal receiver faults aligned along the average east-northeast trending normal faulting nodal plane from the YHS catalog. d) ΔCFS map for normal receiver faults aligned along the average west-northwest trending normal faulting nodal plane from the YHS catalog.

Figure S4. ΔCFS with seismcity during various time periods before and after the Ocotillo event. Left) Left-lateral receiver faults shown in Figure 1 of the main text. Dashed lines show the outlines off geographical Regions I-III as defined in text. Right) Normal receiver faults. Top row) Seismicity for 5 days before (black) and 5 days after (gray) the Ocotillo event from the YHS catalog. Bottom Row) Seismicity for 25 days before (black) and 25 days after (gray) the Ocotillo event.

Figure S5. ΔCFS due to the Ocotillo event for $\mu\prime$ in the range of 0.3 to 0.7. Left) Left-lateral receiver faults shown in Figure 1 of the main text. Dashed lines show the outlines off geographical Regions I-III as defined in text for ΔCFS in panel *c*. Right) Normal receiver faults. Top row) $\mu\prime = 0.3$. Middle Row) $\mu\prime = 0.5$ (as shown in text). Bottom Row) $\mu\prime = 0.7$.

Figure S6. Interferograms of surface displacement constructed from ENVISAT SAR images (descending track 356) show right-lateral surface displacement aligned with the OCO source fault and the east branch of the Laguna Salada Fault following the OCO earthquake. Pairs of dates indicated on each figure are the dates of the first and second image capture used to make the interferogram, respectively. LS-W: Laguna Salada Fault, west branch; LS-E: Laguna Salada Fault, east branch; YWFZ: Yuha Well Fault Zone; YF: Yuha Fault. (C. Rollins personal communication September 2015)

Figure S7. Comparison of total mixed populations (from the summed event rates from population A that received a positive stress step and population B which received a negative stress step at the time of Ocotillo and the M_w4.5 events) for logarithmic stressing histories (red; presented in purple in Figure 6 of the main text) and linear stressing histories (blue). Inset tables lists the best-fitting RSF parameters for the models with linear stressing histories.

Figure S8. Example Omori log-likelihood surface. Contoured here are the values of the log-likelihood for the pre-Ocotillo seismicity in Region I (Figure 3b) as a function of the Omori parameters c and p (K is projected out of the problem by using the optimum K for each combination of c and p). The values that give the maximum likelihood is indicated by the black diamond. Black contour lines are at integral powers of two less than the maximum likelihood. The red contour is at 6 below the maximum, the value our synthetic tests show is the appropriate one to use for 95% confidence intervals. Because we are only fitting to data after 5 days post-EMC (due to magnitude of completeness concerns) we have essentially no constraint on values of c less than 5 days. There is a severe trade-off between c and p such that neither one can be constrained separately, but all the Omori predictions from values within the red contour are similar and fit the data well (see the gray bands in Figures 3 and 4), and therefore departures from their post-Ocotillo extrapolations are an accurate indication of the effect of the Ocotillo stress step.