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FOCAL MECHANISM ANALYSIS OF THE 2010 EL MAYOR-CUCAPAH AFTERSHOCK SEQUENCE IN THE YUHA DESERT REGION

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Introduction

Our originally proposed project goals were to compute focal mechanisms for over 4,000 aftershocks that occurred in the Yuha Desert following the El Mayor-Cucapah (EMC) earthquake. However, Yang *et al.* (2012) computed focal mechanisms for these events during their analysis of all earthquakes in southern California from 1981 through December 2010. Therefore, we were able to use their results to move ahead to the next phase of this project which includes the Coulomb stress change modeling of the Yuha Desert in response to both the M_w7.2 4 April 2010 El Mayor-Cucapah and M 5.8 14 June 2010 Ocotillo, California earthquakes. Interest in the effect of Ocotillo event on the Yuha Desert was driven by the results of Kroll *et al.* (2013) shown in Figure 1. This figure shows aftershocks following the EMC earthquake in red, and those that follow the Ocotillo event in blue. These results led to the hypothesis

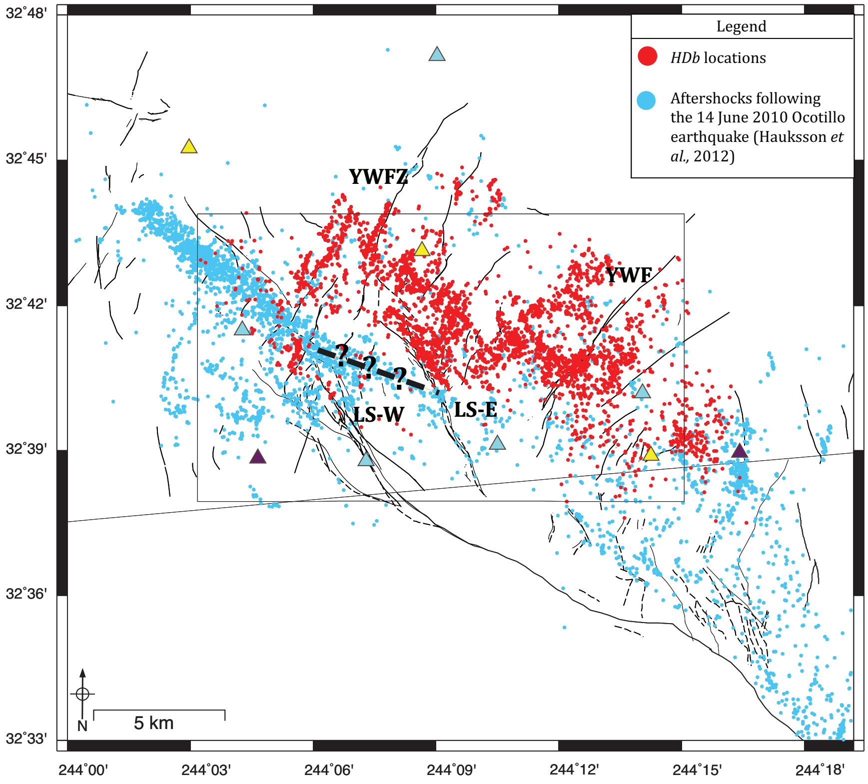

Figure 2: Relocated aftershocks showing potential shut down in the Yuha Desert east of the Laguna Salada - West, following the M5.8 Ocotillo earthquake.

that a Coulomb stress drop lead to a reduction, or shut down, of seismicity in the area east of the Ocotillo rupture zone. This report and the work herein were conducted by Ph.D. student, Kayla Kroll at UC Riverside.

Initial Results

To address whether a decrease in seismicity follows the M5.8 Ocotillo earthquake, we first compute the Coulomb stress change due to this event. Figure 2 shows the Coulomb stress change on vertical, left lateral faults striking N20E due to a source fault shown in green; the source fault dimension is inferred from the extent of the Ocotillo aftershock distribution (magenta). Figure 2 also depicts the seismicity (Hauksson *et al.,* 2012) between the EMC and Ocotillo events (black) and after the Ocotillo event (magenta and green). Earthquakes that occurred in the region of large Coulomb stress decrease (red polygon) are shown in green. Initial inspection suggests that there are far fewer events in the red polygon following the Ocotillo event than before, and with the majority of the aftershocks occurring along the Ocotillo rupture plane and to the southeast in an area of increased Coulomb stress. Figure 3 shows the rate of seismicity verses time (days) following the EMC for events within the red polygon. Shown are events that occurred during the 71-day period between the EMC and Ocotillo events, and the 71 days following the Ocotillo earthquake. The red line notes the time of the Ocotillo event. Seismicity rates are

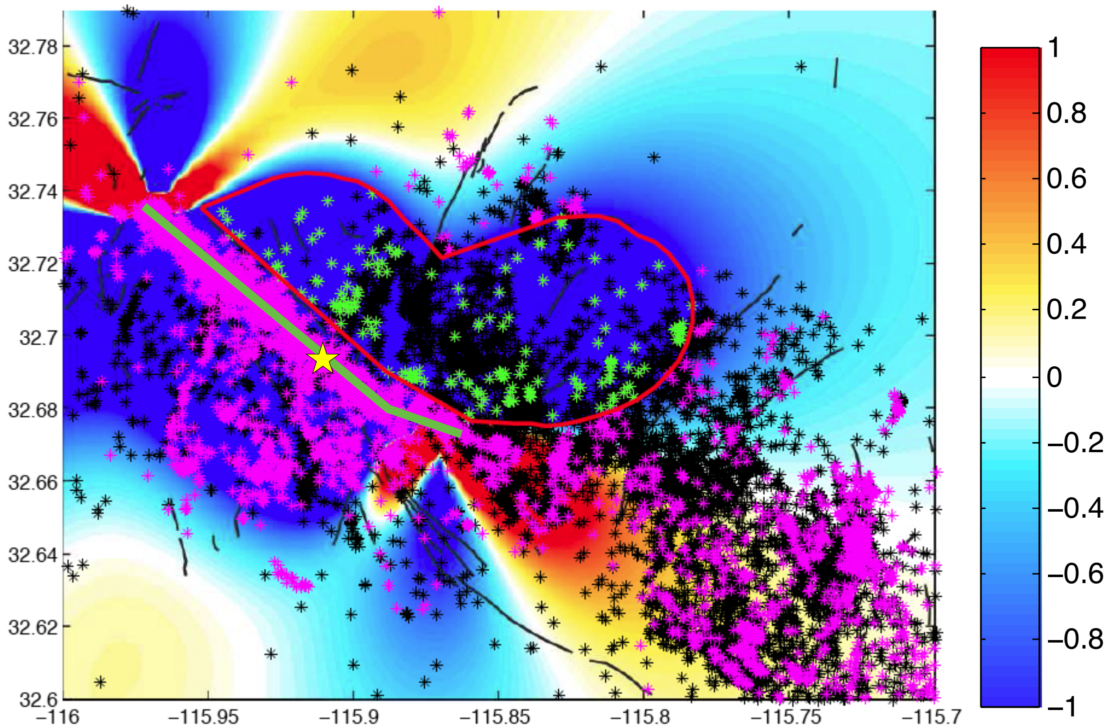

Figure 3: Coulomb stress change (bars) following the 15 June 2010 M 5.8 Ocotillo, CA earthquake (source fault - green line; hypocenter - yellow star). Seismicity between the EMC and Ocotillo is shown in black, with aftershocks of the Ocotillo event shown in magenta and green (Hauksson *et al.,* 2012). Red polygon shows area of maximum Coulomb stress decrease, where seismicity rate is analyzed.

expected to decrease significantly in this region if the Ocotillo event creates a 'stress shadow'. While Figure 3 does show a dramatic decrease in rate following the Ocotillo event, we can't conclusively determine from this plot if the decrease is due to the Coulomb stress decrease or a more typical Omori-like decay.

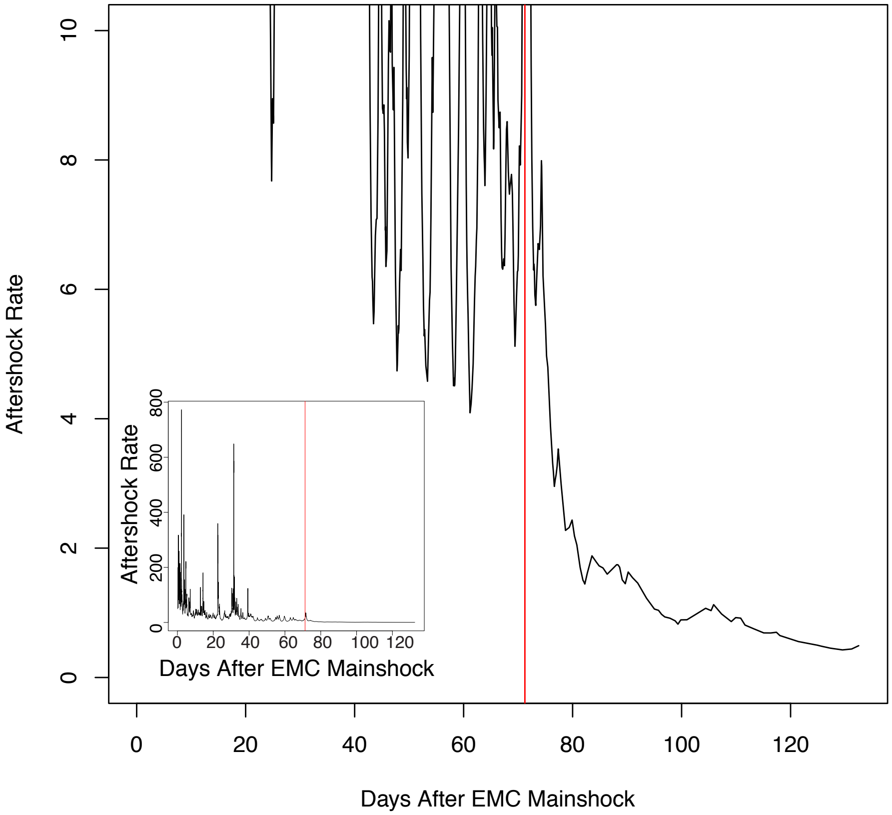

Figure 4: Seismicity rate formulation of seismicity shown in the red polygon in Figure 2. A decrease in seismicity rate is observed in this area following the Ocotillo event.

We also compute the Coulomb stress change on the nodal planes of the focal mechanism solution. We assume that the plane with the maximum stress change due to the Ocotillo event is the plane on which slip occurred. The maximum Coulomb stress change on either nodal plane is shown in Figure 4, for aftershocks of the Ocotillo event, where focal mechanisms have been computed (Lin *et al.,* 2012). The focal mechanisms with the largest Coulomb stress change are along the source fault plane (green), with marginal stress changes observed for events to the southwest of this plane, and larger increases toward the southeast. However, the majority of aftershocks east of the Ocotillo rupture, however, show negative Coulomb stress changes. This result does not preclude the possibility of a shut down in seismicity as the rate-and state- formulation would predict a decrease in the seismicity rate with a negative stress step, rather than a complete shutdown of seismicity (e.g., Dieterich *et al.*, 2000).

A smoothed map of seismicity rate change is presented in Figure 5. For this analysis, the study area is binned and number of earthquakes per bin are summed and compared to a reference state for each bin. The plot is smoothed with a Gaussian smoothing algorithm, which depends on magnitude of completeness. For the purposes of this calculation, the 67 days between the EMC and Ocotillo event are summed per bin as used as the reference rate. The rate per bin in the 67 days following the Ocotillo event was compared to the reference rate. Figure 5 shows an increase in seismicity rates along the northern portion of the Ocotillo rupture, as well as an increase in seismicity rates SW and NE of the rupture. These areas correlate with the regions of increased Coulomb stress shown in Figure 4. Most striking, however, is the area of large seismicity rate decrease coincident with the red polygon in Figure 1. While this analysis is fairly simplistic and does not adequately account for the Omori decay in aftershock occurrence, it may suggest that there is a reduction in the seismicity (i.e. a shut off) in this area. To further address this hypothesis, we will undertake a study similar to that of Dieterich *et al.* (2000) to invert for stress changes based on seismicity rate changes.

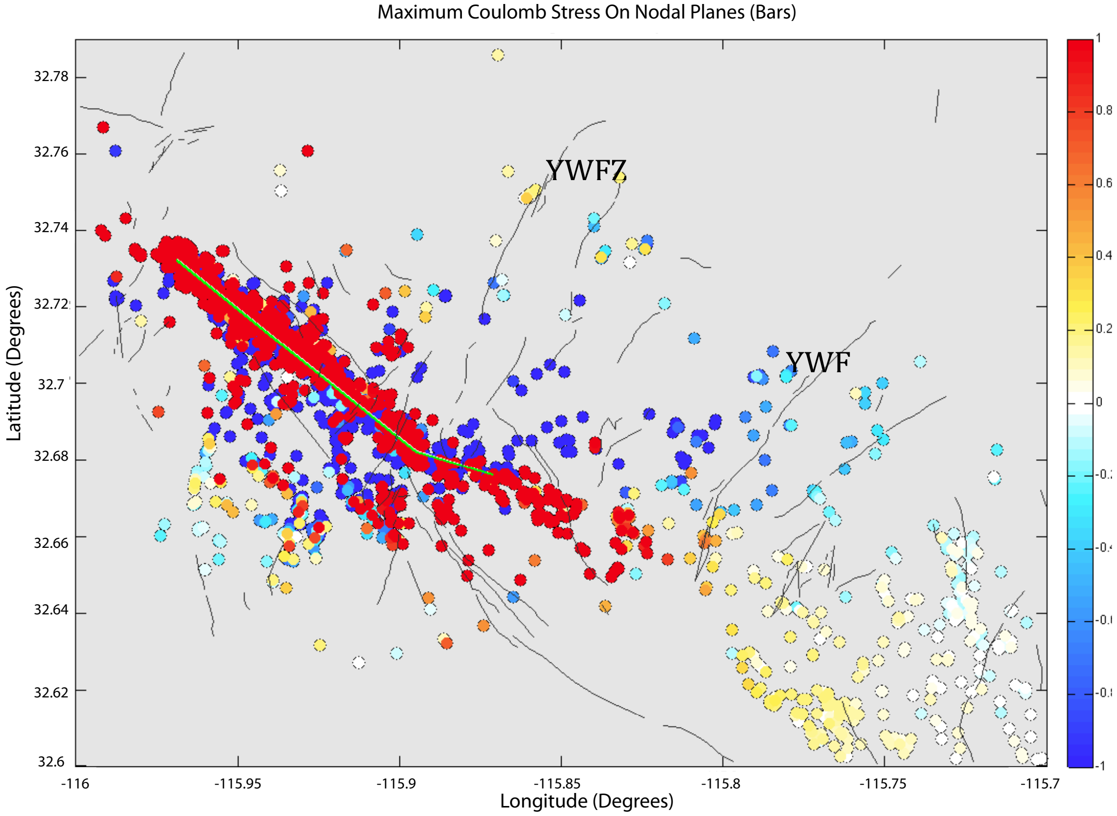

Figure 5: Maximum Coulomb stress change on either nodal plane of the aftershock focal mechanisms following the Ocotillo earthquake. The largest Coulomb stress changes are for events along the source fault plane (green), while marginal stress increases are seen for events to the SW and SE of this plane. Events in the Yuha Desert region primarily experience negative stress changes due to the Ocotillo event.

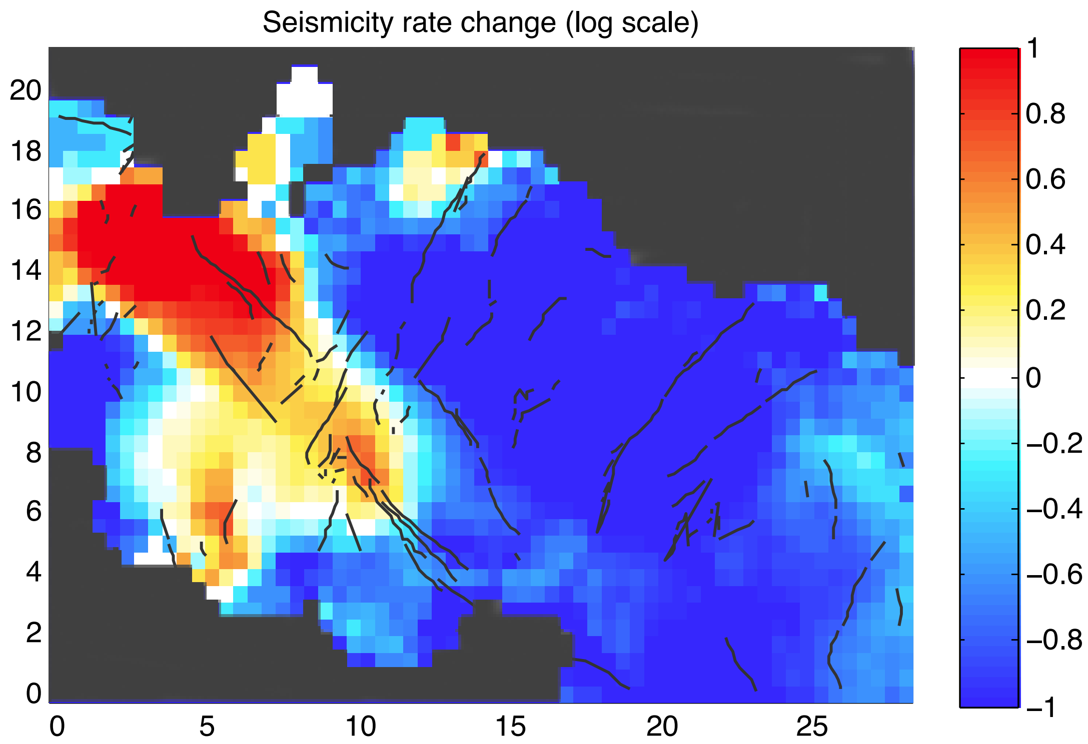

Figure 6: Seismicity rate change calculated for 67 days following the Ocotillo mainshock compared to the 67 day period between the EMC and Ocotillo events. Red areas show an increase in seismicity rate, while blue shows seismicity rate decrease. Gray areas mark regions of insufficient data, where the calculations are not performed. The key feature of this plot is the blue area of seismicity rate decrease that coincides with the red polygon on Figure 2, implying a decrease in seismicity.

References

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