Dear Prof. Ben-Zion,

We would like to thank you, and the two reviewers for their constructive comments on our manuscript 2016JB013632 entitled “**Detailed Spatio-Temporal Evolution of Microseismicity and Repeating Earthquakes following the 2012 Mw7.6 Nicoya Earthquake**”. We are hereby submitting a revised manuscript, of which all the comments have been carefully addressed. Following are point-by-point responses to the comments. We marked the original comments as **bold**, our reply as regular font, and new text inserted/revised in the paper as *italic*.

Best regards,

Dongdong Yao, Jacob I. Walter, Xiaofeng Meng, Tiegan E. Hobbs, Zhigang Peng, Andrew V. Newman, Susan Y. Schwartz and Marino Protti

**Reviewer #1 (Formal Review for Authors (shown to authors)):**  
  
**1. L13. "the 2012 moment magnitude 7.6 Nicoya earthquake"  
  
It would be more informative to add the date of the event occurred (September 5) as the time period for the matched-filter analysis is mentioned (July 1 through December 31, 2012 at L21). With the current abstract, it is not clear if this time period (July 1 - December 31) would cover the foreshock period or not.**

We add the date of the main event to the text. The detection window is from June 29 2012 through Dec 30 2012 (we also updated L21), which covers the foreshock period. However, we mainly focus on the aftershock period as stated in L110 and L159-160.  
  
**2. L21. "approximately 17 times more events".  
  
This "17 times" is compared with WHAT? The 7,900 relocated events? Please clarify it.**

Yes, the number of newly detected events is ~132,900 and it’s about 17.1 times when compared to the number of relocated events (~7750). We change the text to “*approximately 17 times more than template events*”.  
  
**3. L31. "while other alternative mechanism triggers"  
  
It would be more informative to say what would be a possible mechanism. Does this "alternative" correspond to the "subducted seamounts." (L440)?  
  
Related to this, the argument of the subducted seamounts seems to be not well established. For example, I was not able to see "seamounts" in the Discussion section. In other words, "seamounts" is suddenly showed up in the Conclusion section.**

Thanks for pointing this out. We made conservative assumptions and conclusions for the earthquake cluster near the southern edge of the Peninsula because it is somewhat outside the study area and not the focus of our current manuscript. It’s a region devoid of significant afterslip, indicating a possibly different triggering mechanism, such as Coulomb static stress change [*Chaves et al.*, 2016]. We change the text to “*while aftershocks in the SE group are to the SE of the observed updip afterslip and poorly constrained*”.  
  
**4. Equations (1) and (2).  
  
It would be more informative to include unit for each parameter. For example, d is slip. We will have d in m or cm from Equation (2)?**

We thank the reviewer for pointing this out. We add the unit for the scalar potency [Ben-Zion, 2003] in equation 1). In the calculation, we change from [km2\*cm] to [m3] and compute the corresponding circular radius r (in m) as well as averaging seismic slip d (in m).

**5. L234. "We were able to relocate approximately 7,750 events".  
  
It would be more informative to add the time period for these 7,750 events (i.e., the catalog starting from 2012 June?).**

We add the time period for catalog events we start with in the text as “*from 06/19/2012 to 12/30/2012*”.  
  
**6. L289-292. "In addition, there was a gap between the seismicity beneath the Peninsula and offshore seismicity (with depths between 10-15 km) as well as a clear cutoff edge for seismicity to the northwest (Figure 1b).  
  
This argument would be true, but it is very hard to find which figures we can see this "gap" with the depth between 10-15 km. From Figure 1b, we cannot identify the event depths.**

Due to the geometry of the network, the depths for offshore events are poorly constrained. But the depth for the aforementioned gap may be more visible in Figures 3d and 3e, including the area devoid of seismicity offshore at a depth about 15 km.   
  
**7. L322. "larger cumulative slip"  
  
It might be more informative to have a table showing the total cumulative slip for each repeating earthquake sequence.**

We added another table showing the cumulative seismic slip for each repeating cluster as Table S4 (Cumulative seismic slip for repeating sequences).   
  
**8. Figure 1 and its caption.  
  
It would be more informative to add the time period of the events shown in this figure. Also, the yellow star would be the epicenter of the mainshock. The caption does not say what the yellow star is.**

We added the time period of the events shown in the figure (see point 5). We made changes to the figure caption by adding the sentence “*The yellow star marks the mainshock epicenter*”.  
  
**9. Figure 3. L777-778. "a local three-dimensional velocity model (red circle; Moore-Driskell et al. [2013])"  
  
I read this sentence that Moore-Driskell et al. [2013] provided red circles. But Moore-Driskell et al. [2013] provided a velocity model and this manuscript provides the relocation (red circles).**

We rephrased the sentence to: “Seismicity located using SimulPS (blue circles; *Walter et al.* [2015]) are shown with TomoDD relocations (red circles) found using with a local three-dimensional velocity model [*Moore-Driskell et al.,* 2013]”.  
  
**10. Figure 4. L784. "to 12/30/2012"  
  
This might be "to 12/31/2012"?**

It should be “from 06/29/2012 to 12/30/2012”.  
  
**11. Figure S4b.  
  
Mc=1.3 is obtained. I thought the b-value (or red line) would be fitted to the data well down this Mc (from M~6). But it seems that the fit is good down to 1.8-2.0 only. I was just curious why the fit is not good between 1.3-1.8.**

We computed the magnitude of completeness (Mc) for the different catalogs using the best-combined method in ZMAP [*Wiemer*, 2001]. We update Figure S4 by combining both panels to show simply the frequency-magnitude relationship of the template catalog and detected catalog. One reason that the fit is not good between 1.3 and 1.8 could be that there were still missing events in this magnitude range, especially right after the mainshock.

**12. Table S1 and S2.  
  
"mag" is ML?**

Yes, we change to ML.   
  
**Reviewer #2 (Formal Review for Authors (shown to authors)):**  
  
**My main questions involve the discussion of cumulative slip as measured by repeating clusters and the postseismic afterslip. It appears that the authors have not complied with AGU's data policy in the acknowledgments.**

We add the following sentence in the Acknowledgments: “*Supporting data include 4 tables, and can be obtained from the Nicoya Seismic Cycle Observatory (NSCO) Data Product Repository (http://nicoya.eas.gatech.edu/Data\_Products)*”.

**Major points  
  
Lines 378-391 Comment on the coseismic slip and repeating events occurring on the interface as being evidence of loading by afterslip which I believe is supported. The results section however comments in lines 311-324 that most repeating clusters occurred in areas that are near the edge of or devoid of modeled afterslip. Wouldn't most repeating events according to the velocity weakening asperity model surrounded by velocity strengthening aseismic slip therefore be expected to occur in the region of highest modeled postseismic afterslip? Could the reason for this be that there are fewer asperities in a large velocity-strengthening zone that is most easily captured by the geodetic data? Is it because of possible poor spatial resolution of the postseimic afterslip model? Repeating events have been called creep meters at depth and so may therefore give better spatial resolution of afterslip than land based geodetic measurements? Could another reason be that the repeating events on the edge of the largest coseismic slip experience the greatest stress step from the mainshock if the maximum coseismic slip is greater than the maximum postseismic afterslip?**

We mention in the Discussion section that aftershocks not only occurred in regions partially overlapping with the major afterslip, but also along patches devoid of significant observed afterslip. This has similarly been observed for both tremor and microseismicity along the Hikurangi subduction zone [Bartlow et al., 2014]. One hypothesis for this behavior could be that velocity-weakening asperities are surrounding large velocity-strengthening patches (where major afterslip occurred) and progressive Coulomb stress changes develop from the adjacent propagating afterslip front. Consistent with the general aftershock spatial patterns, we also observed repeating events cluster where little afterslip occurred. Hobbs et al. [2016] show a checker-board test for spatial resolution of the afterslip model, and those patches with major afterslip (immediately offshore) are within the recoverable areas. Hence, we believe that the observed ‘anti-correlation’ between aftershocks and afterslip is real.

**It may be useful to have another figure with a histogram of the distribution of total cumulative slip for all the clusters as it is hard to see from Figure 10b. The text states the largest was 60 mm but what is the mean value? What fraction of the plate rate is this? As far as I could find the text doesn't state what the maximum and mean modeled coseismic and postseismic slip are which would also be useful to know.**

We include another supplementary figure (Figure S5) showing the histogram of the cumulative seismic slip for all repeating clusters (as well as Table S4 listing the values).  **Figure 8, Why is there more scatter in the tomoDD results? Is it because tomoDD just uses phase data and not correlation data? Or is it because different templates detected the events and are assigned different locations. Or a combination of both? Why would there be so many different template events for this cluster if that is the case unless there aren't that many detected events? Some comments should be made on this because both hypoDD and tomoDD have the ability to invert phase and correlation data and should give comparable results. Perhaps take the labels of tomoDD and hypoDD off because it seems like it is not a comparison of the location programs as much as it is the type of data inverted.** The panel c) and d) are not relocation results from different tools (tomoDD/hypoDD) using the same dataset. Actually, c) panel shows the locations of those repeaters (from the tomoDD relocation in section 4.1) before we applied the refined relocation using waveform cross-correlation differential time, while d) shows the refined locations. We change the labels to “*Before Refined Relocation*” for panel c), and “*After Refined Relocation*” for panel d). As stated in section 3.3, the waveform cross-correlation differential time could help to obtain sub-sample accuracy, which helps to explain why the c) panel looks more scattered compared to the refined locations in d).

We agree with the reviewer that both hypoDD and tomoDD have the ability to invert both phase and correlation data and should give comparable results. While in our study, we didn’t combine the correlation data in relocating the template catalog, since it included ~7890 events across a large region. The correlation data could improve relative locations, but considering the trade-off between the potential improvement and computational cost we decided to relocate all events with the catalog phase data. The reason for inclusion of cross-correlation differential times for the repeaters is that sub-sample differential time accuracy is needed for verifying the overlapping ruptures of repeating clusters. In addition, the event numbers are much smaller and hence relatively easy to manage. We added the following sentences to clarify at L217-227: “*As mentioned before, we relocated all 7890 catalog events using only catalog phases in TomoDD with a refined 3D velocity model, which could help to constrain both the absolute and relative locations. We didn’t combine with waveform cross-correlation differential time mainly because the catalog includes events across a wide region, and it would cause more computation cost when compared to the potential improvements on relative locations. On the other hand, to confirm whether events have overlapping rupture patches within each cluster, we further relocated them in HypoDD [Waldhauser and Ellsworth, 2000] with a simple 1D velocity model by applying waveform cross-correlation differential time with sub-sample accuracy to reduce relative location errors [Schaff et al., 2002]*”.

**Minor points  
  
Line 15, The relocated events are 7750, shouldn't this then be ~7800?**

We started with 7890 events before running TomoDD, and some events were dropped either due to relatively larger residuals or they became “air-quakes” (locating with negative depth values). After certain number of iterations, we ended up with 7747 events with relatively well-constrained locations. We clarified this at L246.

**Line 158, "activities"**

Done

**Line 214 members?**

Done

**Figure 6, the legend seems to be incorrect**

We double check the legends and make sure they are correct.

**Additional author-directed change**

Figure 4: we updated the moment magnitude for the largest aftershock of the 2012 Nicoya mainshock by change the legend to “Mw6.4 Aftershock”