Author response to reviewers (our words in red)

General:

We agree with the reviewers that our contribution has attempted to cover a lot of ground, some not exclusively related to the new data presented on the Lake Muir earthquake sequence. With this in mind we have trimmed the manuscript discussion. However, we retain insight that the Lake Muir sequence has contributed to regarding stable continental region earthquakes. Further, we expand the introduction to appeal more to the international readership of Solid Earth, and better scope our stable continental region focus. One area of concern for both reviewers was the degree to which deductions on earthquake genesis and relationships to faulting may be made from our main shock locations and aftershock relocations. We recognise that the uncertainties relating to earthquake locations were not well-communicated, and have rectified this deficiency. Specifically, we note that the uncertainties on aftershock locations are better than 300 m in all cases. The reviewed manuscript presented the initial Australian National Seismic Network locations for the three largest events in the sequence as these events failed key tests for double-difference relocation. This resulted in the undesirable situation where the main shocks were associated with horizontal location uncertainties of 5-6 km. In the revised manuscript we have relocated the two largest events based upon the relatively well located third largest event in the sequence. This relocation has resulted in collapse of the horizontal location uncertainty ellipses to ~ 1 km, and allows for better comparison between main shocks, aftershocks, and surface and geological data. The revised Figures 3 and 6 are attached as an example of the improvement.

Reply to specific comments made by EC1:

- "I suggest focusing on the characterization of the seismic sequence, its surface deformation and propose some explanation for the longer ruptures in comparison to the commonly used scaling relationships". The focus of the manuscript has been reframed in the introduction, and the relationship developed between visible surface rupture length (VSRL) and detectible surface rupture length (DSRL) removed as suggested. We instead consider the relationship of our new results to existing empirical scaling relationships, and propose possible explanations.
- "Comprehensive figure where the data are integrated". It is not clear what the reviewer desires here. Figure 6 presents the InSAR results as a base, with the relocated epicentres, and rupture traces from field mapping and InSAR (black and white lines respectively) overlain. The only data not presented on this figure are the UAV data, which are presented in Figure 7. We feel that combining the UAV data with Figure 6 would unnecessarily clutter the figure. Or does the reviewer refer to his comment on Section 4.1.3, which is addressed below?
- "Title: Change in the title the part dealing with rethinking Australian stable continental region Earthquakes": Title text after the colon modified to more concisely introduce the paper content: "new insight into Australian stable continental region earthquakes"
- "For an international journal it would be more appropriate an introduction presenting data on moderate magnitude seismic sequences, their associated surface deformation and surface breaks (length)". We have rewritten the Introduction to better set the scope of the manuscript. We retain our focus on the stable continental region (SCR) setting, but have presented our study in the framework of global SCR earthquakes that precede the Lake Muir sequence, many of which have been imaged by InSAR. Table 1 has been expanded considerably to present data relating to these earthquakes.
- "Is it possible to better explain the meaning of grain in the landscape or add a reference for it?". We mean grain in the same way that trees have grain; a preferential alignment of constituent elements. To clarify, the word 'grain' in the sentence has been replaced with "an alignment of valleys and ridges".

- "At lines 285-295 the Authors infer fault geometry by aftershock distribution… To me this dataset is not enough to depict fault geometry". As a preamble to addressing this reviewer concern we note that in response to reviewer RC1 misunderstanding our aftershock deployment geometry we have added text to section 2.3 and to the caption of Figure 2 noting that the rapid deployment kits are prefixed by LM on Figure 2. We have also stated the uncertainties associated with the aftershock relocations in the text of Section 3.4, which was not made clear before. The mean location uncertainties in the relocated dataset were calculated to be 63 m, 116 m, and 228 m in the east, north and up directions, respectively. It is true that the computed aftershock distribution does not define a neat rupture plane, nor are relocated earthquakes so numerous, as may be the case in the plate margin examples presented by the reviewer. However, given the tight uncertainties we contend that the scatter is real, and the main concentration of aftershocks 'in general' occupy a volume defined by positive coulomb stress changes. As the reviewer notes, this relationship is not 100%. This stems in part from the 'real' scatter, but mainly from the limitations in depicting the 3-D aftershock cloud in 2-D sections. The hypocentres occurring at depth immediately beneath the rupture plane, within a volume of modelled coulomb stress decrease, mostly relate to the November M_W 5.2 event. This is, however, not exclusively the case, implying the presence of foreshocks on the November rupture plane. We have tightened the text of Section 3.4, and the caption of Figure 8, to improve the clarity of communication of our observations.
- Section 3.5. "Relationship between moment magnitude and surface rupture length amongst Australian cratonic earthquakes. I suggest removing this paragraph". As this section was of concern to both reviewers, we have removed it. Instead, we consider the relationship of our new results to existing empirical scaling relationships, and propose possible explanations, in the discussion.
- Section 4.1.3. Co-location of thrust and strike-slip events: This is a quite big speculation since the resolution of the data do not allow for this, or data are not well presented to convince the reader about this. Provide an integrated picture to support the co-location. We must conclude that there are deficiencies in our presentation of the data as the evidence from the INSAR images is compelling and incontrovertible for an overlap of surface deformation envelopes resulting from the two largest events. This is explicitly stated in the text and is shown in Figure 6, where the surface trace of the strike-slip fault rupture relating to the November event (panels c and d) has been superposed onto the surface deformation pattern of the September event (panels a and b). We agree that there is significant uncertainty in relating the main shocks and aftershock distribution to geological structures. We have reworded the section to recognise that this is secondary evidence supporting the primary correlation using InSAR.
- Section 4.1.3. "The sentence starting at line 443… In general, the volume in which aftershocks are located corresponds to a volume of positive Coulomb stress change resulting from the main shock (Figure 8)", is not 100% consistent with aftershock distribution… I suggest to significantly reduce this part and incorporate it in the discussion on the seismic sequence". As mentioned above, we have tightened the text in terms of communicating the uncertainties associated with the hypocentral locations. Further, we have provided explanation in the text for the hypocentres that do not occur in the volume of positive Coloumb stress (these mostly relate to the November event). We contend that this justifies retaining the section.
- Section 4.1.4 "Mechanisms for strain localisation in Stable Continental Region (SCR) crust... This paragraph is not strongly related to the data presented in the manuscript but mainly based on literature. I suggest removing this part." We have trimmed this section to focus more on the immediate region of the Lake Muir sequence, then tie this to material presented on global stable continental earthquake mechanisms in the reworded introduction. To remove this section entirely would be to lose a discussion of the insight that the events might give to the setting of SCR earthquakes globally.
- Section 4.2 "One-off ruptures from moderate to large magnitude earthquakes in the cratonic regions of Australia... I suggest removing this part." The section has been shortened and

reworded to emphasise that there is no evidence for prior rupture on the Lake Muir faults, and this is typical of Precambrian SCR crust, as presented in the reworded introduction.

- Section 4.3. "Migration of the locus of moment release in the Southwest Seismic Zone… I suggest deleting it" This section has been deleted as suggested. A few sentences have been incorporated into the revised section 4.2 for clarity of argument.
- Section 4.4. Deleted as suggested.

Reply to specific comments made by RC1:

- Section 2.3. "Rapid Deployment aftershock kits… Regarding the seismic station deployment, the closest station has been located at least at 24 km far from the epicentral area of both earthquakes... large uncertainties might afflict the location of small magnitude earthquakes occurred during the swarms". The reviewer misunderstood our communication of the experimental design. The nearest ***permanent*** network station is 24 km from the epicentral area. This is explicitly stated in the text. The five rapid deployment aftershock kits range in distance from right on top of the first main shock (LM01), to 42 km distant (LM05). We have added text to Section 2.3, and the caption of Figure 2, to make clear that the black triangles with labels prefixed by 'LM' on Figure 2 are the temporary stations. We understand that the network, comprising permanent and temporary stations, is not as dense as might be achieved in regions where there is a higher perception of earthquake hazard (i.e. non-SCR), but are satisfied that our uncertainties (better than 300 m for aftershocks) is suitable to make our conclusions.
- Section 3.5. "In my opinion this latter argument [new relationships between moment magnitude and surface rupture length] deserves a separate paper. The paper should be more focused to the expected results introduced by the title." This section has been removed as suggested by both reviewers.
- Line 445-448. "They don't clearly explain if they consider the November earthquake induced by a dynamic triggering of the September event …I think the clarification of this point could be an important statement for future and more addressed studies, for instance the fault ruptures interaction or the dynamic triggering between two or more seismic sources.' Excellent point! The text has been modified to reflect the fact that we do indeed think that the second M5 event was triggered. Further, comparison to the other 'swarm events' in Australia which comprise M5 events suggests that mechanical interaction of 'blocks' results in subsequent proximal (or co-located) triggered events. We demonstrate in this article that the triggered events can have different failure mechanisms.
- "in Figure 6a there is an east-west oriented fringe interruption at latitude/longitude 6190000/4790000? How the Authors interpret it?" The text of Section 3.2 states "Coherence is also partly lost beneath an approximately 2 km wide (N-S) easterly trending band of pine forest (see Figures 3 and 6a for location)". The north-south extent of this forest is clearly marked with an arrow labelled "pine forest" on both Figures 3 and 6a. We have added the following text to the caption of Figure 6: The north-south extent of an easterly trending band of pine forest associated with degradation of coherence is indicated with a white arrow in part (a).
- "For a "not Australian" reader is a bit hard to follow the text with the lack of a clear tectonic map containing the bright place names tags." Figure 1 *is* a clear tectonic map as far as stable continental region crust may be divided with respect to seismogenic potential (e.g. Johnston et al 1994; Clark et al. 2012). In the revised manuscript, we have either included all Australian place names mentioned in the text in Figure 1, or written explicit locations into the text itself.