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Natural Hazards and Earth System Sciences Discussions

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Interactive Comment

Interactive comment on “Source model of 18 September 2004 Huntoon Valley earthquake estimated from InSAR” *by* W. J. Lee et al.

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We sincerely appreciate the useful comments from reviewer #2.

Q1. InSAR Processing is a bit confused. Indeed, the use of large time span interferograms, particularly on ascending orbits, seems to be unjustified. The risk to include post seismic effects is not negligible and should be properly taken into account during modeling. This also implies the inclusion of many other seismic events that occurred after the 18 September one, as for instance those of around 2008, that can influence the retrieved cumulative displacement.

A1. From the NCAeeDD catalog, there were three earthquakes with Mw > 5.0 on 18 Sept, 2004. However, the amount of ground surface deformation produced by an earthquake is highly controlled by its magnitude and depth (Okada, 1985). So we focused our research on the MW 5.6 event. Accordingly, we added the following sentences at page 2-3: "NCAeeDD catalog reported three earthquakes: Mw 5.6 (3.26 km depth), MW 5.2 (7.15 km depth), and MW 5.4 (8.76 km depth). Generally, ground surface deformation produced by an earthquake is highly controlled by its magnitude and depth (Okada, 1985). Moreover, based on the simulation study of Dawson et al. (2007), InSAR is generally insensitive to the deformation of an earthquake with magnitude less than 5.5 and depth larger than 6 km. The surface deformation from the Mw5.6 earthquake is much larger than the combined deformation from the other two events. So, the observed deformation is mainly due to the Mw 5.6 event. Therefore, in this study, we focused on the Mw 5.6 earthquake which occurred at 23:02:17 (UTC) and compared the InSAR-derived source model parameters with those from the Mw 5.6 event." In addition, we used SBAS (Small BAseline Subset) InSAR algorithm to increase the temporal sampling of the deformation time series. We added a new subsection 3.1 'Time-series deformation' and concluded that the postseismic deformation, if any, should be included in the coseismic interferograms.

Q2. The large temporal baseline could strongly affect the InSAR coherence. Since no information on the general coherence behavior of the scene has been provided, it is difficult to evaluate the impact of this aspect on the resulting averaged deformation maps.

A2. The study area maintains InSAR coherence higher than 0.3 even when the perpendicular baseline or the temporal baseline is large. Based on the reviewer's comment, we added coherence/interferogram figures (Fig 3 and Fig 4) and the following sentences in the revised manuscript: "The coherence of a repeat-pass interferogram highly depends on its perpendicular and temporal baselines. Fortunately, the study area maintains interferometric coherence value greater than 0.3 in spite of large perpendicular baseline and/or temporal baseline (Tables 2 and 3). This is because that Huntoon Valley is located in an arid semi-desert region with little vegetation. Fig. 3

shows coherence images which were calculated from original (not filtered) interferogram. Clearly, Fig. 3(b) and Fig. 3(d) have higher coherence because of short perpendicular or temporal baselines (Table 2). Other interferogram pairs used in this study have coherence value greater than 0.3 (Fig 3). The higher coherence of interferograms in this study allowed us to interpret the deformation results reliably.

Q3. In general, a more detailed analysis (in terms of perpendicular and temporal baseline) on the full available ENVISAT data set should be presented, aimed at justifying why the authors used only the selected interferograms for producing the displacement maps. For instance, Bell at al. 2008 used a different data pair, even if probably on a different track.

A3. Based on the reviewer's comment, we modified the following sentences: "We used the two-pass InSAR approach (e.g., Massonnet and Feigl, 1998) to generate interferograms with perpendicular baselines less than 350 m and temporal baselines less than 5 years from one ascending and one descending tracks, respectively. We then chose 5 descending (Table 2) and 8 ascending (Table 3) co-seismic deformation interferograms whose coherence values are greater than 0.3."

Q4. The generation of the displacement maps should be also better clarified: what "average" means in this case? Are the authors applying any stacking approaches? I suppose averaging has been conducted on unwrapped interferograms: please clarify.

A4. The word 'average' was meant 'stacking'. To clarify the confusion, we added the following sentences: "Considering some of the interferograms were contaminated by atmospheric artefacts, we then carried out stacking method (Biggs et al., 2007) to obtain the co-seismic deformation by reducing atmospheric artefacts. Stacking is a technique that can extract subtle deformation signals out of multiple interferograms. By averaging many interferograms over the same area, random noise such as atmospheric signals can be subdued (Biggs et al., 2007). For earthquakes of this size, it should be noted that the postseimic deformation is negligible compared to the co-seismic part

NHESSD
1, C3009–C3022, 2014

(Segall, 2010). Thus, in this study, the stacked interferogram is dominated by the co-seismic deformation."

Q5. Another confused aspect is the actual improvement that InSAR could give to the seismic catalogues, either global or local. Indeed, InSAR-derived fault parameters seem quite similar to the local catalogue CISN but also to the global one named as PDE, as reported in Table 1.

A5. We showed that the improvement of InSAR-derived source parameters in Fig. 9. Particularly, InSAR modeling results provide better constraints on the location and the strike of the event (Fig. 9, Table 4).

Q6. In addition, authors state that the CMT catalogue parameters are considered as biased, but what about the local NCAeqDD (which presents a Depth value of 3.2 km)?

A6. To address the reviewer's comment, we rewrote the section on '3.2 Comparison of source parameters from InSAR and seismology'.

Q7. Finally, no mention is given on the limitation of InSAR, as for instance the inability to discriminate different events occurred at very close times.

A7. To address the reviewer's comment, we wrote the following in the revised version: "However, InSAR imagery suffers poor temporal resolution, atmospheric artifacts, and sometimes loss of interferometric coherence, making it difficult to resolve postseismic signal."

-Minor Point-

Q1. P 4291 line 2. the expression within brackets depends on the orbit direction. The projection of the same displacement vector along the LOS has different impact on ascending and descending passes. Q2. P 4291 line 5-6. What "r" is? What u_asc, u_dsc are?

A1+A2. The LOS vectors from the ascending and the descending tracks are represented by u_asc and u_dsc, which are calculated based on the corresponding θ and φ from the ascending and descending tracks, respectively. We added the following sentences: "u is a matrix containing unit LOS vectors (u_asc, u_dsc) which can be calculated based on the corresponding θ and φ from the ascending and descending tracks, respectively. r is a vector representing the LOS deformation measurements (observations) from interferograms of both ascending and descending tracks."

Q3. P 4292 lines 14. please use International units

A3. Fixed.

Q4. Fig.2. Please indicate millimetres instead of radians. In addition, the indication of "LOS direction" in panel (a) and (b) should be inverted. A4. Fixed.

Q5. Table 1 and Table 4. please use correct sign for longitude values

A5. Fixed.

Please also note the supplement to this comment:
http://www.nat-hazards-earth-syst-sci-discuss.net/1/C3009/2014/nhessd-1-C3009-2014-supplement.pdf

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 1, 4287, 2013.

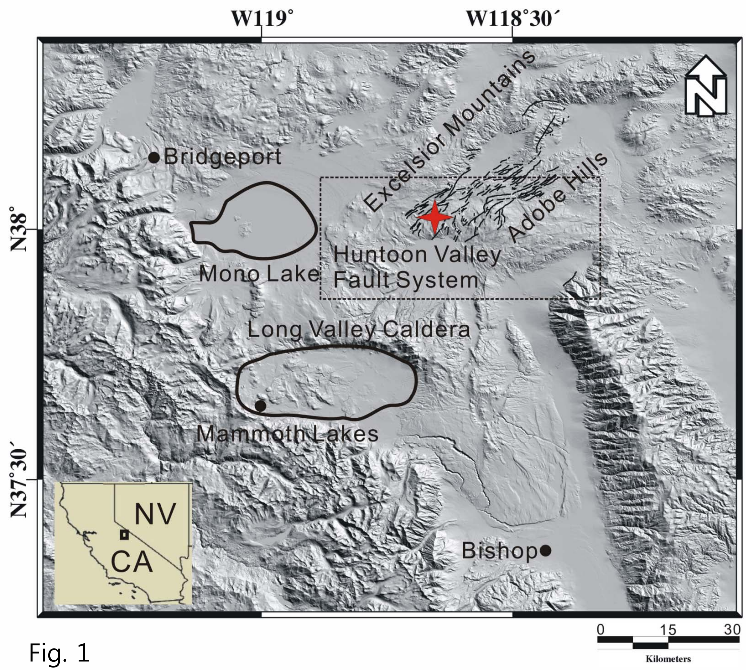

Fig. 1

Fig. 1. Shaded relief map of Huntoon Valley and surroundings

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Interactive Discussion

Discussion Paper

NHESSD
1, C3009–C3022, 2014

Interactive Comment

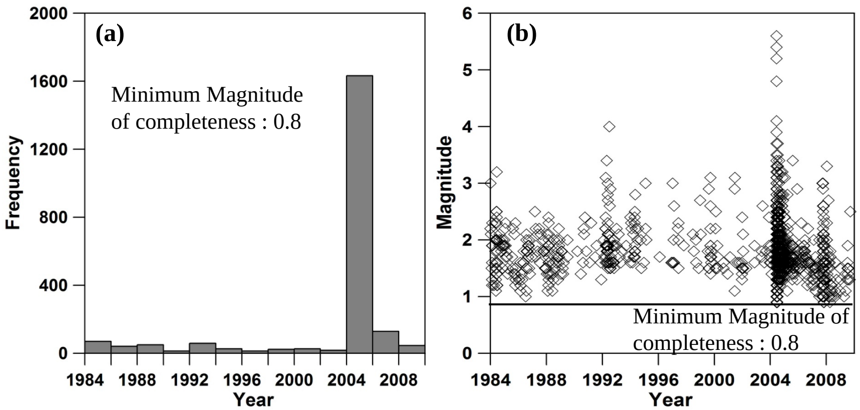

Fig. 2

Fig. 2. Distribution of (a) frequency and (b) magnitude of earthquakes

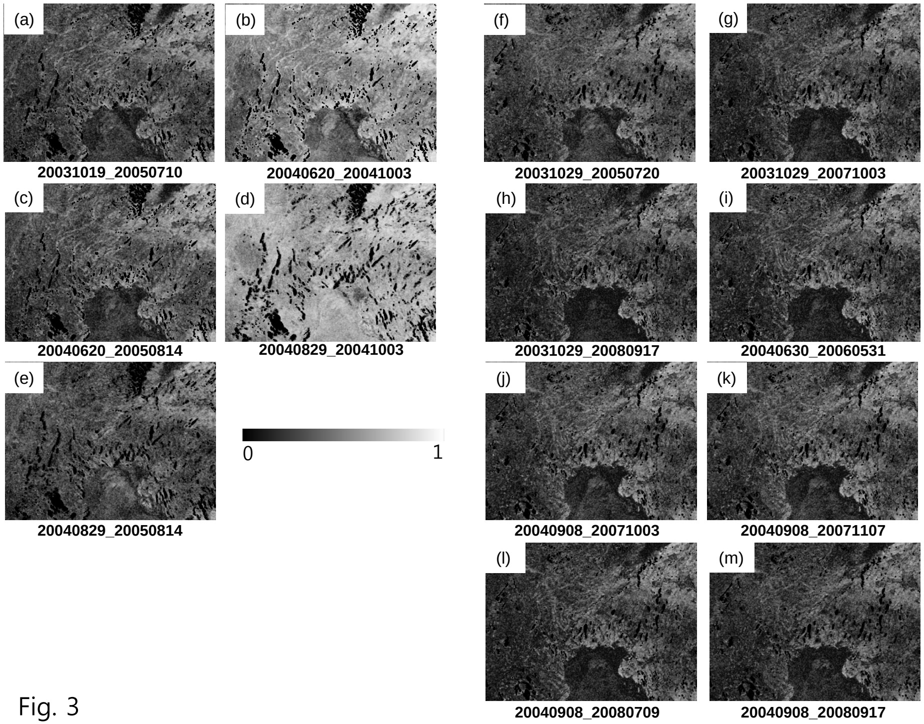

Fig. 3. Coherence maps

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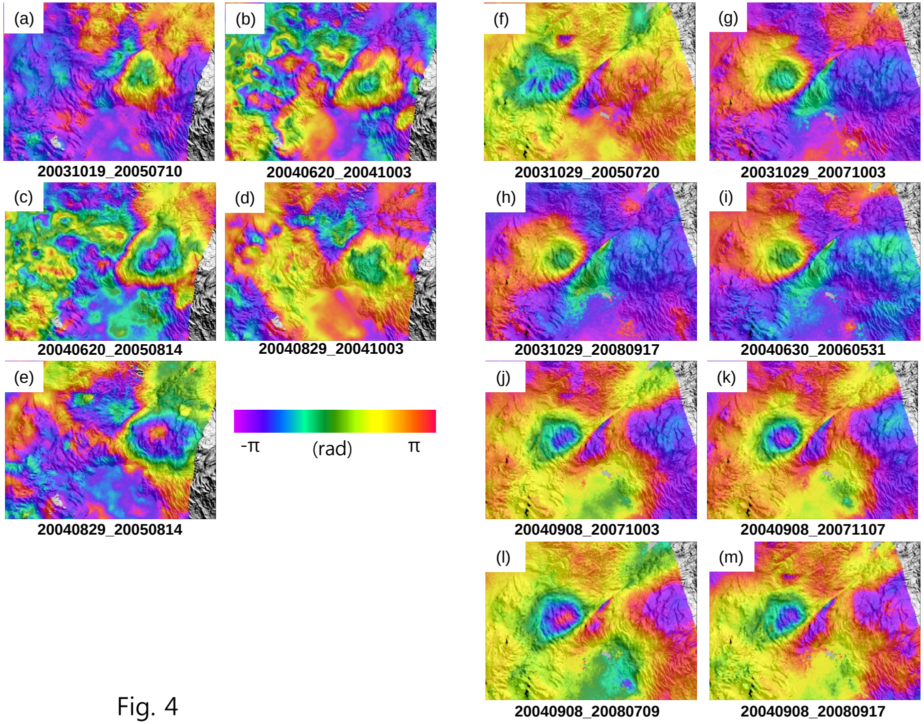

Fig. 4

Fig. 4. Wrapped interferograms

NHESSD

1, C3009–C3022, 2014

Interactive Comment

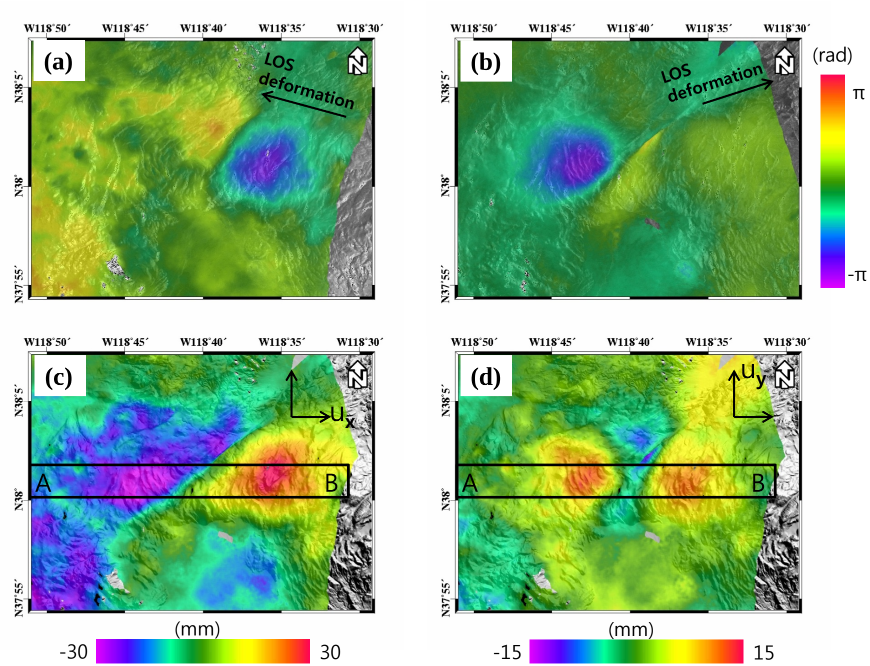

Fig. 5

Fig. 5. Deformation images

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NHESSD

1, C3009–C3022, 2014

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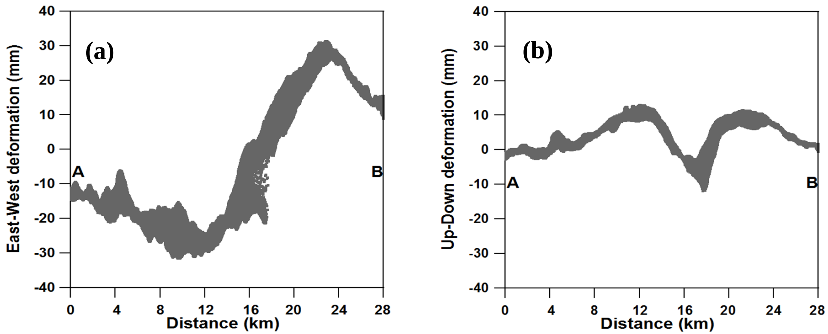

Fig. 6

Fig. 6. East-west (a) and vertical (b) components of the deformation

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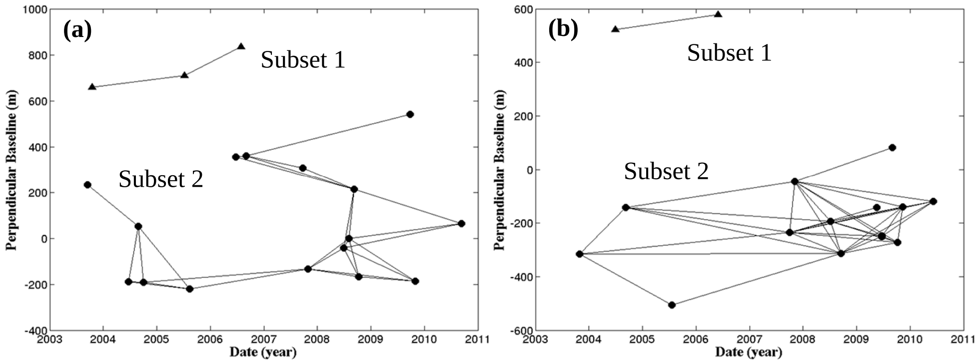

Fig. 7

Fig. 7. Perpendicular baselines used for SBAS InSAR processing

NHESSD

1, C3009–C3022, 2014

Interactive Comment

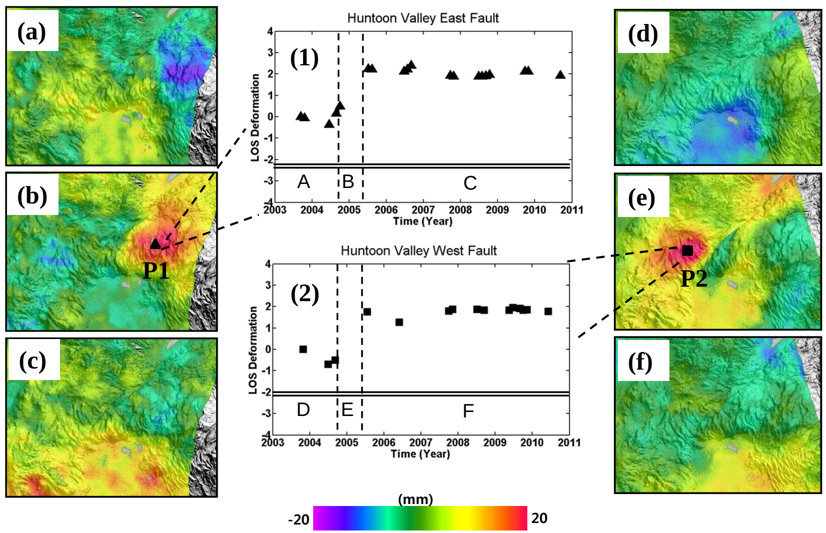

Fig. 8

Fig. 8. Time-series surface deformation

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Interactive Discussion

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NHESSD

1, C3009–C3022, 2014

Interactive Comment

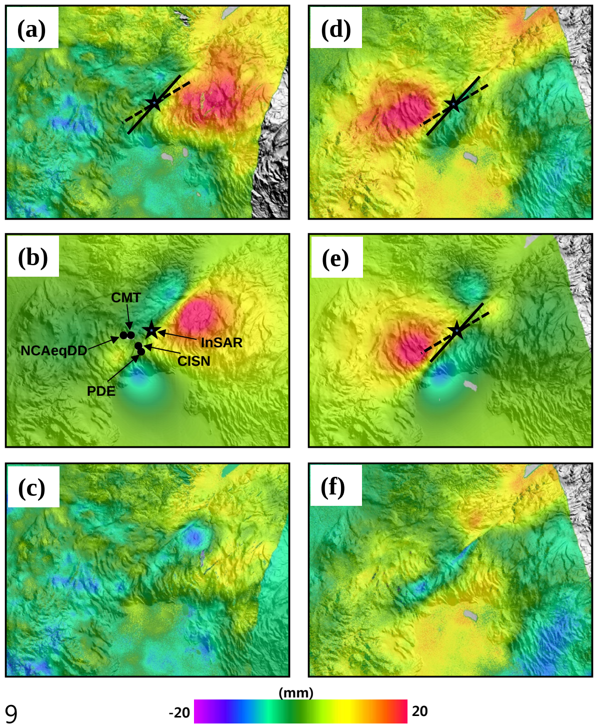

Fig. 9

Fig. 9. Observed and modelled deformation images

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