

Interactive
Comment

Interactive comment on “Landslide dynamics and coupling revealed by L-band InSAR in central Georgia” by E. Nikolaeva et al.

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Replies to comments by “Anonymous Referee #2”,

Comments of the anonymous referee were found very useful. Below we provide the reviewers suggestions followed by our answer.

COMMENT: Specific comments and technical corrections: P5, L1, a mistake of 10-mm yr⁻¹. Here authors show the temporal deformation scale, while the spatial deformation different in magnitude and direction is another main problem to be considered.

REPLY: We appreciate this comment and made appropriate changes.

COMMENT: P5, L6, "common InSAR" should be replaced by "traditional 2

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pass differential InSAR".

REPLY: Changes made.

COMMENT: At the end of the first paragraph in section 3.1, authors should give some brief explanations of the functions of four data involved and then give detailed description as follows.

REPLY: We used all available data for study of landslide. Remote sensing data (optical and radar) served to define landslide and determine its the active area.

COMMENT: P7, L 25, exactly to say, it is better to use "pixel posting or spacing" rather than "resolution".

REPLY: We appreciate this comment and made appropriate changes.

COMMENT: The accuracy of GDEM and SRTM DEM (1 arc sec?) should be discussed and the propagation of DEM error to deformation are beneficial to the differential interferograms analysis.

REPLY: We did not observe a significant difference between these two dataset. We added this brief comment and a description of the accuracies of the two different dataset into the discussion section.

COMMENT: What's the landslide type in this research? rotational, translational or complex one? In my view, the inverse models are different for different landslide type, so do the volume estimation. Authors should focus on the one and give more detailed description.

REPLY: We considered the landslide as complex (Fig. 10). A detailed explanation is given in the discussion section.

COMMENT: Please give all parameters of SAR interferometric pairs, accordingly, the InSAR deformation errors can be analyzed. Moreover, the precision or accuracy of In-SAR results is missed.

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REPLY: We appreciate this comment and prepared a new table. Please, find a table with parameters of SAR interferometric pairs in the supplement file.

COMMENT: If the temporal evolution of landslide is expected, the best way is to use SBAS method, especially for the later trigger factor analysis.

REPLY: Unfortunately, due to lack of data, SBAS does not work well in our case. We tried it.

COMMENT: Regarding the arrangement and explanation of Fig. 4, it confuses me, such as Fig. 4(1,2,3) is refer to A, B, C or (1), (2) and (3), so do Fig. 4(1-3). And in the Figure 4, please re-arrange the sub-figure sequence in chronological order as the daily deformation rate is considered, and give the time duration for each figure after perpendicular baseline. I also find some figures have not been discussed in the whole text. Besides, the InSAR quality is low for some monitoring duration, such as the images shown in D and H. Please give more discussion of InSAR results before inversion of the landslide geometry.

REPLY: We changed in the text: 'Fig. 4 (C) presents locations of profiles (Fig. 4 (1-3)), which clearly indicate that no displacement ... '. We changed Fig. 4 follow your recommendations.

COMMENT: In the main text, please correct the figure label of Fig. 5 and Fig. 6 with capital, not low cases, make sure the consistence with the corresponding figures. P15, L21, temporal baseline is 92 days, not 90 days.

REPLY: We made appropriate corrections as suggested.

COMMENT: As far as landslide volume is concerned, please clarify the type of landslide, is it the deformed landslide or geomorphologic landslide, as the surface areas are significantly different as mentioned in the text.

REPLY: Geomorphologic landslide is the correct term. We made appropriate changes in the text.

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COMMENT: In section 4.3, refer to Okada dislocation inversion, firstly, the three interferograms are not well consistent with each other, regardless the thermal noise. So the errors of deformation should be analyzed and tried to mitigate in advance, such as DEM error, artifacts or phase unwrapping errors.

REPLY: We appreciate this comment. The general shape of the three interferograms is very consistent. However, as pointed out by the reviewer, the amplitude is different. To double check the quality of the inversion results, we used interferograms with different level of errors to test their influence to the result. Output results show minor variation of parameters.

COMMENT: Secondly, as for a specific landslide, the mostly changeable parameter is dip slip dislocation component, especially for the temporally non-linear landslide, whilst the changes of any other parameters can be neglected. Therefore, in technical mean, you'd better fix some parameters in order to achieve good inversion results.

REPLY: In our analysis, we fixed some parameters for modeling, as detailed in the revised manuscript.

COMMENT: Currently, the inversion results are not convinced, and the errors will propagate to volume estimation. More importantly, the inversion of depth and dip angle and geometry and the validation are key to landslide mechanism research and landslide hazard mitigation and prevention.

REPLY: We are agree. We presented first rough estimation of volume.

COMMENT: Some errors exist in Table 1, such as the 2nd column of 46 and 92 days and in title, (Fig. 8A-C).

REPLY: We corrected them.

COMMENT: Again, as for the extrinsic factors of landslide movement discussion, the prerequisite is the reliable InSAR time-series deformation results and even dense resolution in time domain.

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REPLY: We agree. Unfortunately, there is not enough data in the archive. This we critically discuss in the revised discussion section.

COMMENT: P16,L11, 0.3km and 1 km should be transposed.

REPLY: Changed made.

COMMENT: Fig. 9 is confusing, please give more detailed explanations in caption and in main text. It's hard to analyze temporal correlation between surface deformation and precipitation within four different areas. Precipitation data should be collected from metrological station (real data), not the simulated model (ECHAM5). You'd better change the scheme. As a result, no obvious correlation between deformation and precipitation can be found. Actually the lagging between deformation and precipitation should be carefully considered. (see e.g. Hilley et al., 2004, Science; Chaoying Zhao et al., 2012, Remote Sensing of Environment)

REPLY: We agree. Unfortunately, there is not metrological station close to landslide, which we describe in a more detailed discussion section. Also we are now much more careful with the interpretation of the rainfall information. To this aim we also consider the papers by Hilley et al., 2004 and Zhao et al., 2012.

COMMENT: P18, L27, make sure the $MI = 3.8$ and in Line 25 $Mw = 6.0$ are correct. And in this paragraph, please indicate two earthquakes in Fig. 9.

REPLY: They are correct (<http://seismo.iliauni.edu.ge/>). The lines with ball on the top indicate two earthquakes in Fig. 9.

COMMENT: The discussion of mining factor to landslide is too qualitative to be convinced. More investigation data should be imposed.

REPLY: The private mining companies are not willing to provide any information. We added in the discussion: 'Our work suggests the landslide to have a decade long history, which is developing. From Landsat imagery we see that the man-made activity has significantly increased. Our own survey and questioning of residents further

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supported the fact that the mining activity has strongly increased in the past 8 years. One may speculate that the effect of man-made activity on land sliding may even more augment as unloading in the toe region continues. Moreover, as the landslide is hence further developing, also interacting processes, such as earthquake or rainfall triggering may alter with time. Therefore, a close observation and further work with a more regular data acquisition is needed, allowing to detect displacement rate changes at higher detail. Also a monitoring of the mining activity may help to clarify the impact man-made actions do have on natural hazards. In this view, the Itskisi landslide may provide an excellent laboratory, where such interacting and cascading processes might be well studied'.

Please also note the supplement to this comment:

<http://www.nat-hazards-earth-syst-sci-discuss.net/1/C1730/2013/nhessd-1-C1730-2013-supplement.pdf>

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 1, 4925, 2013.

NHESD

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