Landslides triggered by the 2015 Mw 6.0 Sabah (Malaysia) earthquake: inventory and ESI-07 intensity assignment

Response to Editor

I wish to thank the editor for the thoughtful comments, which helped in improve the quality of the manuscript. Here I provide a point-to-point answer to all the comments. Original comments are shown in *italic*, while my answer is in plain text.

***Comments to the author**:*

The editor suggests that the author make the additional following corrections before publication :

- Line 25 : distinction between « primary effects » and « ground shaking » ?

Primary effects include surface faulting and the permanent deformation of the topographic surface; with “ground shaking” I mean all those effects on the natural and built environment that are due to the passage of seismic waves. New text is as follows:

Moderate to strong earthquakes cause widespread damage due to primary effects (i.e., those related to the seismogenic source, which include surface faulting and permanent ground deformation) or due to ground shaking (i.e., related to the passage of seismic waves).

- Lines 187 and 190 : fig.4 instead of fig. 3

Done.

- Lines 193-194 : could the author add a plot showing the comparison between predictions of landslides occurrence from USGS model and the true distribution of failures in the paper or in the supplementary material to support this statement ?

Agreed. I added as supplementary material a map showing the expected distribution of landslides according to the USGS model and the actual distribution. The map is appended below.

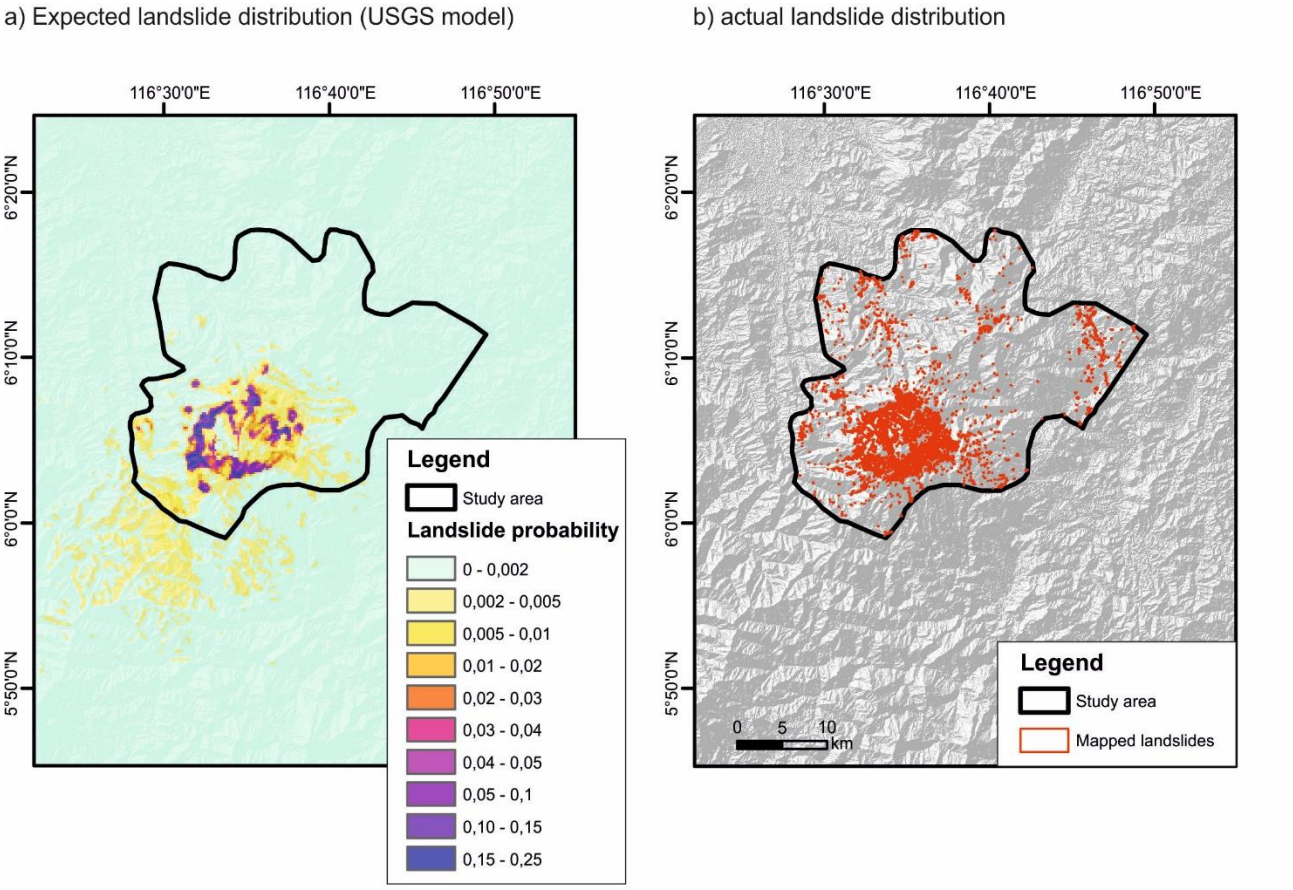

Figure S1: a) Expected landslide distribution, extracted from USGS website; b) actual distribution of mapped landslides.

- In LAP, fig.4, add %

Done.

- ESI-07 degrees are based on landslide volumes categories defined by ranges of 1 order of magnitude span. Changes in the AV laws does not imply a change in the resulting volumes by one order of magnitude. That may explain why modifying the AV law does not change the final distribution of ESI-07 local intensity (cf. maps of Fig.5). Observed differences between the ESI-07 maps associated to the different laws are related to landslides whose volumes are close to the upper and lower boundaries of the categories defined by the ESI-07 degree scale. Therefore the comment of lines 215-216 should be modified accordingly.

Agreed, I added the following sentence:

This is because ESI-07 degrees are based on broad categories in terms of volume (each category span at least one order of magnitude, Table 2); observed differences between the ESI-07 maps are related to landslides whose volumes are close to the boundaries defined in the ESI-07 scale.

- Fig 5 : complete the legend to describe what plots a to g show. Same for plot h.

New caption is as follows:
Figure 5: Grid maps of ESI-07 local intensity obtained by adopting different area-volume scaling relations (a: Guzzetti et al., 2009; b: Larsen et al., 2010 – all types; c: Larsen et al., 2010 – bedrock; d: Larsen et al., 2010 – soil; e: Xu et al., 2016; f: Benjamin et al., 2018; g: Caputo et al., 2018); h: frequency of cells belonging to the different ESI-07 classes for each scaling law.

- *Lines 305-306 : as mentionned by the author, we can not exclude that the higher number of landslides in the Sabah earthquake is only due to the fact that the inventory was realized 8 months later, therefore incorporating also remobilizations. This leads to comparisons with other earthquakes being treated with caution.*
Agreed, new text is as follows:
I realized the inventory on satellite images acquired 8 months after the earthquake, thus slope movements triggered by processes other than the mainshock may be included, such as debris flow remobilization. This implies that comparison with other earthquakes should be gingerly considered.

- *Table 4 : are LAP values given in this table in % ? If so, please add « % » in the legend. Are more than 2 digits meaningful ?*
Agreed, and corrected accordingly.

- *Line 314 : LAP may better represent ESI-07 because ESI-07 is based on volume and volume on area, right ?*
I expect generally to be true, but still not necessarily. A similar LAP may be obtained by many small landslides, or by one bigger landslide. ESI-07 depends on the biggest landslide in a cell unit. For instance, Figures 3a and 3b both have LAP = 0.36, but different ESI-07 values. The new text is as follows:
Median LAP values instead do not show such inversions, eventually suggesting that LAP is a better descriptor than LND for assessing the damage. This fact is not surprising, since LND has a “point” validity, while LAP is related to an area assessment, which should generally be more consistent with volume (on which ESI-07 values are based).

- *Line 360 : the meaning of this sentence is not clear to the editor.*
The text has been rephrased as follows:
Currently, institutions such as USGS produce Shakemaps and ground failure estimates in the immediate aftermath of strong earthquakes. These provide information on the expected earthquake

effects using different descriptors. Maps are expressed in terms of intensity (Modified Mercalli scale) or ground motions (PGA, peak ground acceleration and PGV, peak ground velocity); maps of expected environmental effects (landslides and liquefaction) are produced as well.

- Fig. 9 : it should be explained into more details : how were selected the boundaries of each ESI-07 scale for LND parameter for instance ? How can we tell looking at Fig. 8 ? The median value is only one parameter : therefore is it used to define the lower or the upper boundary of each ESI-07 class ?

Thanks for the comment. I realized that the type of graph I selected was conveying unclear information. I changed the graph style, making it similar to Figure 8. Points represent the median values; I believe the new graph is more consistent with the preliminary nature of the data currently available. The analysis of more case studies will allow to derive class boundaries of each ESI-07 degree on sound statistical basis.

In the text, I changed the description referring to Fig. 9; the new version of the figure is appended below. New text:

In Fig. 9, the median LND and LAP values derived for the Sabah earthquake are compared to the thresholds proposed by Xu et al. (2013). Both intra- and inter-event variability can be noticed: the application of different area-volume relations results in different estimates of LND and LAP for the Sabah case history; one possible way to handle the epistemic uncertainty due to the existence of different area-volume scaling laws is to include them in a logic tree, where each branch has a weight defined by the modeler. Fig. 9 also shows that thresholds proposed for the Wenchuan earthquake (Chinese intensity scales) are lower than the values obtained for Sabah (ESI-07 scale).

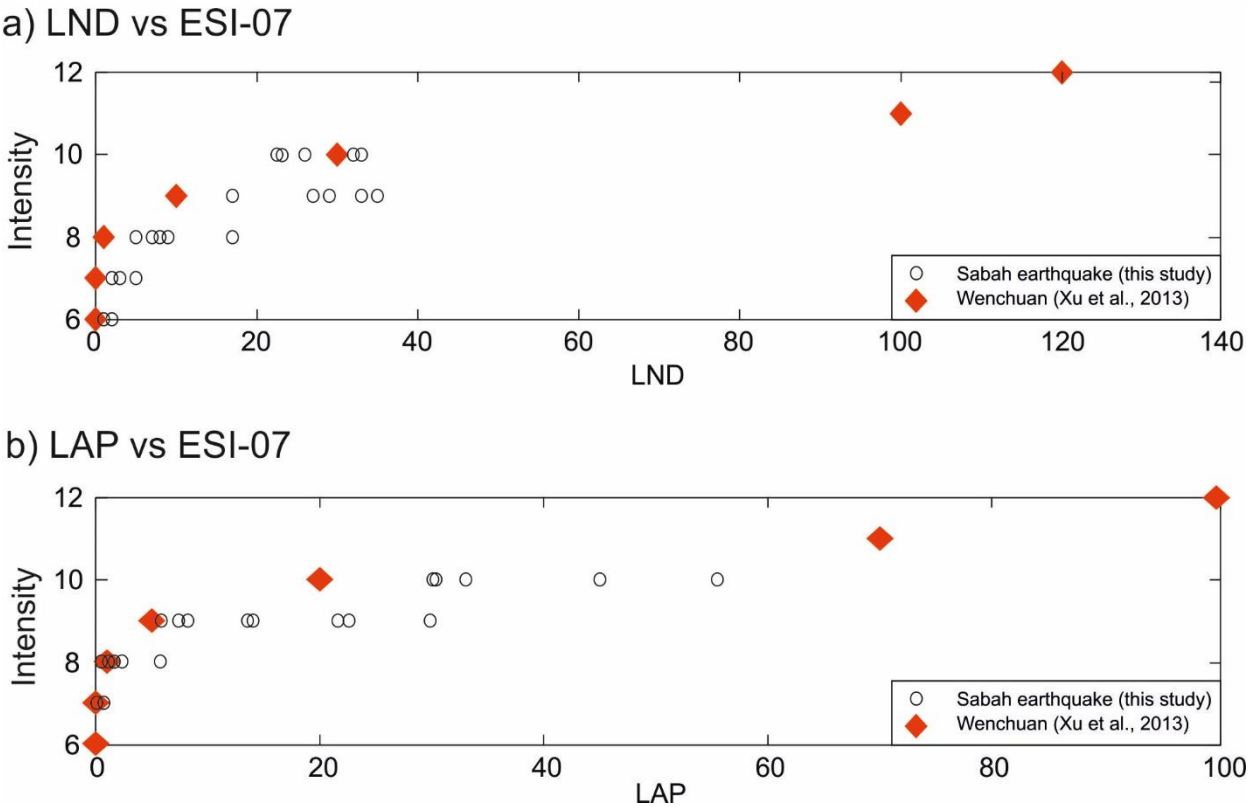

Figure 9: Plots of LND (a) and LAP (b) vs ESI-07 values; small black circles are the median values for the Sabah earthquake, obtained with the different scaling laws. Red diamonds are the values proposed by Xu et al. (2013) for the 2008 Wenchuan earthquake.