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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Landslides triggered by the 12 January 2010 Mw 7.0 Port-au-Prince, Haiti, earthquake: visual interpretation, inventory compiling and spatial distribution statistical analysis" *by* C. Xu et al.

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We deeply appreciate the comments and suggestions of Referee 1 that improved our manuscript significantly. We appreciate the positive comment on our inventory of the landslides triggered by the Haiti earthquake. The inventory is one of the major points of this manuscript. Complete inventories of earthquake-triggered landslides are important for future studies, but we feel that the current available data is still not enough. Thus one of our main purposes is to provide a complete inventory of the Haiti earthquake-

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triggered landslides to such databases. We have revised and modified this manuscript following the comments and suggestions of Referee 1. We will reply to some major points of the comments below:

(1) About the choices of parameters: We understand the referee's concern that many of the parameters we have chosen to analyze in this study may well turn out to not have significant influence on the earthquake-triggered landslide distribution. Of course, strong ground shaking, steep topography and specific geologic conditions have been commonly considered as major factors of co-seismic landslides. However, as more and more research and analysis about earthquake-triggered landsides have been carried out recently, several other factors have been proposed to have played some roles in the spatial distribution patterns of co-seismic landslides, such as slope aspect, topographic positions, the movement habits of seismogenic faults. This has been shown in several recent publications. For example, the slope aspect was not considered as an important factor in the past, but in the 2008 Wenchuan and 2013 Lushan earthquakes, it did affect the distribution of co-seismic landslides, probably due to relations with seismic wave propagation directions or block movements. Therefore, we decided to analyze as many factors as possible, in the hope to identify new controlling factors of co-seismic landslides. We believe this would stimulate future analyses and discussion on new potential co-seismic landslide controlling factors. We do, however, agree with the referee that we do not need to show all of the relationships as figures when there do not seem to be a significant influence. We have modified our figures to reflect this.

(2) About the indication of categories in figures and text: We appreciate the comment of the referee. We have changed the figures and use the variable quantities themselves in the figure.

(3) About the graphs: The four variables plotted in our graphs are two commonly used indexes (landslide centroid and landslide area) and two new indexes (landslide top point and landslide erosion thickness). These indexes represent different methods of expressing the co-seismic landslides. Therefore, we think it is better to put them

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together in order to compare these indexes. However, as mentioned above, we agree with the referee that some of the relationships do not show significant correlations and may be dropped. We have modified our figures to reflect this.

(4) About the comparison with the Enriquillo-Plantain Garden Fault (EPGF): We agree with the referee's concern that the Enriquillo-Plantain Garden Fault (EPGF) was not actually the seismogenic fault. According to most investigations, it is generally agreed that the actual seismogenic fault is likely the blind Léogâne fault. It would be perfect if we construct the co-seismic landslide relationship with along-strike and perpendicular-to-strike distances of the Léogâne fault. However, since this fault is blind, the actual trace of the fault is unknown, and the surface geomorphic expression of the fault is unclear, we had difficulty constructing such relationships. Instead, the EPGF is a known fault that can be traced readily in the maps, and is sub-parallel to, and only a few km south of the Léogâne fault. Moreover, many aftershocks of the earthquake show strike-slip focal mechanisms (Koehler & Mann, 2011), which is consistent with the EPGF. Therefore, we chose to construct the statistical analysis based on the EPGF. This is just for the statistical analysis and will not influence the result, and does not indicate we think the EPGF was the actual seismogenic fault. We have added several sentences in the text to reflect this.

(5) About the east-facing slopes: The slope aspect is a recently noticed co-seismic landslide factor. It is shown in the 2008 Wenchuan and 2013 Lushan earthquakes that it affect the distribution of the landslides. This is probably due to relations with seismic wave propagation directions or block movements. In the 2008 Wenchuan earthquake, footwall-facing slopes had more landslides in the hanging-wall block, probably due to the inertial force asserted to the slopes during the earthquake. The focal mechanism of the Haiti main shock had a significant striking-slip component. Therefore, we think the east-facing slopes in the southern block of the seismogenic fault had similar situation. We have added several sentences in the text to show this.

(6) About the PGA distribution: The PGA map is downloaded from USGS in vector for-

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mat with 0.04 g intervals. The USGS PGA data have been updated several times after the earthquake considering the earthquake parameters, focal mechanism solutions, regional tectonic setting, and topography. We understand the referee's concern that it would be better to use a coarser interval to perform the analysis. However, a ∼0.2 g analysis interval would mean only 3 different PGA classes in the entire area, and may not provide much more meaningful results. Therefore, we think the USGS PGA data provide good enough information in this area without good near-field seismic station coverage. We have added a section in the text to discuss this.

Detailed comments and recommendations as sticky notes in the manuscript:

(1) Line 9 of page 1264: There is controversy concerning whether or not fault rupture occurred. Some in the USGS maintained that the fissures along the San Andreas trace were not fault rupture but were landslides and other cracking. Others within the USGS disagree and hold the view that much of the cracking on Summit Ridge is fault rupture spread across a wide zone of right-lateral deformation and that the complex crack orientation is a result of block rotation within the zone of deformation Harp, E.L., 1998, in Keefer, D.K., ed., The Loma Prieta Earthquake of October 17, 1989- Landslides. Origin of fractures triggered by the earthquake in the Summit Ridge and Skyland Ridge areas and their relation to landslides, US Geological Survey Professional Paper 1551-C, p. 129-143. Reply: we have added a sentence to state the uncertainty of this issue.

(2) Line 24 of page 1267: Not sure what this means. Explain further. Reply: we have rewritten these sentences.

(3) Line 22 of page 1270: Rock falls can occur on dip slopes as well and almost always have significant internal disruption unless you are talking about single blocks. Reply: we have modified this sentence to "Unlike rock falls that can occur on dip slopes and reverse slopes. . ."

(4) Line 1 of page 1271: Replace landslide with rock slide. Reply: changed.

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(5) Line 27 of page 1271: There are certainly parts of the peninsula that did not have landslides, especially in some areas to the north of the EPGF zone. Reply: we have changed this sentence.

(6) Line 9 of page 1272: Why not use the elevation output on Google Earth to get better esitmates of thicknesses and volumes? Reply: The Google Earth elevation may be better for individual landslides. For landslide volume estimation in a regional scale, the area-volume relationship is a common and widely used method.

(7) Line 29 of page 1274: You just stated that the average aspect ratio of Northridge landslides was 4.15 and that the average ratio for the Haiti earthquake was 3.15. Then how can the aspect ratios of the Haiti and Yushu landslides be larger than that of Northridge? Haiti at 3.76 is closer to Northridge at 4.15, not to Yushu. Reply: this is a mistake of ours. The actual average aspect ratio of Yushu landslides is 4.15, and the average aspect ratio of Northridge landslides was 2.6. We have changed the text.

(8) Line 3 of page 1275: This is probably not true. The PGA's at Pacoima Dam were 1.8 g on the abutments, and we have no real measure of PGA's in the Haiti earthquake. Reply: Due to the limitation of precise PGA data for the Haiti and Yushu earthquakes, we can only consider a general situation that larger earthquakes may result in higher ground shaking, without considering specific sites such as the Pacoima Dam. We have modified the sentence to reflect this.

(9) Line 12 of page 1275: from the Wenchuan earthquake Reply: we have added it.

(10) Line 20 of page 1278: Eastward movement on an east-facing slope would have the effect of increasing the stability of the slope during that interval. Westward movement would be the inertial motion to lower the stability of the slope. Reply: as mentioned above, this is likely due to the inertial force, as shown by the 2008 Wenchuan earthquake. We have modified the text to discuss this.

(11) Line 27 of page 1280: Actually the steepest slopes are near the river drainages

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which is why the landslide occurred there preferentially. This is pretty obvious without a statistical comparison. Reply: we agree with the referee. However, additionally, the loose slope materials accumulated near the drainages may also be prone to failure during strong ground shaking. This is reflected in the text.

(12) Line 11 of page 1283: This is a possibility, but there is no independent information to confirm it. It may well not be a branch of the EGPF. Since the earthquake was not on the EGPF, I see no reason to use it as a marker for comparing the landslide distribution. Reply: as mentioned above, the mechanisms of the 2010 Haiti earthquakes is rather complex. We chose the EGPF to conduct the analyses with co-seismic landslides since the actual seismogenic fault is difficult to define. Many aftershocks also show predominantly strike-slip focal mechanisms. Therefore, the EGPF still likely played important roles in this earthquake.

(13) Line 29 of page 1283: I fail to see this in this figure. Actually, the graph shows LCND and LTND higher there than anywhere farther away. Reply: we have changed the sentences to "On the other hand, landslides at 0–2 km from the fault in the southern block show higher LAP and LET increase but lower LCND and LTND increase comparing with other classes (Fig. 25b)."

(14) Line 18 of page 1285: Classes 7 and 8 have no significant difference since we don't know the PGA's with much precision. Reply: we agree with the referee that we do not know the PGA's with much precision. Therefore, we do not emphasize the differences between classes 7 and 8 (PGA 0.4 g and 0.44 g).

(15) Line 26 of page 1285: This section needs to be rewritten for clarity. Reply: we have rewritten the text of this section.

(16) Line 12 of page 1286: This equation seems to suggest that the bigger L is, the lower P is, and that is counter to your argument. I also find the text in this section confusing and hard to interpret. Reply: This equation is just for the perfect case that the landslides are entirely controlled by one impact factor. Thus there will only be one

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L and one P for a particular earthquake. The main point of this section is that, the more landslide abundance differences in different classes, the stronger controls of the factor on landslides. “The shape of this curve would represent the controlling degree of the impact parameter on co-seismic landslides area. If the co-seismic landslide area is only slightly controlled by a parameter, the curve would appear as a straight line and the area percentage under the curve would be close to 50%. In the contrary, if co-seismic landslides were strongly controlled by a parameter, the curve would be a convex curve and the area percentage under the curve would be greater than 50%.” We have re-written several sentences of this section following the suggestion of the referee.

(16) Line 2 of page 1287: This does not seem to be true in all areas of the graphs. Reply: This is shown in Table 3.

(17) Line 2 of page 1290: Again, there is no mechanical basis for this. Westward movement would have the most destabilizing effect on the slopes. Reply: this is discussed above. We have also modified this sentence.

(18) Page 1313: Unfortunately, these maps do not help the reader much at this small scale. They need to be larger. Reply: we have included high resolution files of all figures.

With best regards, Chong Xu and other authors

Please also note the supplement to this comment:
http://www.nat-hazards-earth-syst-sci-discuss.net/2/C787/2014/nhessd-2-C787-2014-supplement.pdf

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