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Interactive comment on “Effects of finite source rupture on landslide triggering: The 2016 M_W 7.1 Kumamoto earthquake” *by* Sebastian von Specht et al.

Sebastian von Specht et al.

specht@gfz-potsdam.de

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Dear Mr . Wang,

thank you for your comments and constructive suggestions, which we considered in detail to improve the presentation of our study. Please find below our point-by-point response to the *original comments*:

1. *In Figure 1 and 5, it is not obvious that Mt. Aso, its caldera, Mt. Shutendoji, Mt. Kinpo and Mt. Otake are near-identical conditions, particularly, the lithology, and topographic characteristics.*

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We used the term "near-identical condition" to outline that the four mountains have all geological young volcanic rocks of similar composition, and that hillslope inclination and MAF are elevated.

2. *In Figure 1, it's true that the landslides triggered by this earthquake are concentrated mainly inside the caldera and the flanks of Mt. Aso. But this area is also nearer the fault rupture patch with highest slip than other three areas. This means more energy could be released from this place during the earthquake. So the difference between distance effect and directivity effect needs to be analyzed.*

   We agree on the statement that energy release is localized in the asperity. We address this by considering the asperity portion only and show the landslide distribution with asperity distance in a new figure (Fig. 5b) and landslide azimuth with respect to the asperity centroid (Fig 6b). Given the extent and steepness of the asperity patch, results change slighlty when compared to the results for the entire rupture plane.

3. *This directivity effect results in larger shaking amplitudes in the rupture propagation direction variations in wave amplitudes and energy related to the directivity effect occur at lower frequencies. The paper shows the total landslide affected area is within 22.9 km distance from the rupture plane. In this near fault area, the effect of high-frequency seismic ground motion on landslide should be more important than the low-frequency.*

   We partly agree on these statements, and see that some clarification is needed. We never stated that the lower-frequency contribution is more important; instead we say that it considerably contributes to the overall shaking and landslide triggering. The majority of landslides has aspects that cannot be explained solely by the lower-frequency ground motion and its associated directivity (Fig. 14). Because of these observations, we base our GMPE on Arias intensity. We also stated at the end of section 5.2 that the Arias intensity is more sensitive towards higher frequency contributions and that it explains most of the data, but not all of them. The ground motion contributions of the lower frequencies—related to energy—is lower than the ground motions at higher frequencies, as shown by our model. Adding an energy term helps to better explain ground motion, though it does by no means explain the entire ground motion. Considering the comments by the reviewer, we recognize that some of our statements are ambiguous. Hence, we made clearer statements in the conclusions.

Changes in text (in page 27, lines 5-6, lines 13-15, lines 22-23.):

We demonstrated that the pattern of coseismic landslides is not only consistent with ground motion at higher frequencies (e.g. distance dependence) but also contributions from lower frequencies are evident.

We introduced a modified model for Arias intensity using site-dependent seismic energy estimates instead of the source-dependent seismic magnitude to better model low-frequency ground-motion in addition to the ground-motion at higher frequencies covered by the Arias intensity.

4. *The coseismic landslide is resulted in seismic load and slope geotechnical engineering conditions. This paper mainly makes an in-depth analysis from the engineering earthquake perspective, but the analysis of engineering geological factors is relatively rare. The conclusion is somehow different from some empirical knowledge. I suggest authors further analyze the influence of engineering geological factors. For example, authors can consider the physical and mechanical properties of rock-soil mass and DEM data with higher accuracy to analyze their correlation with landslide, and use quantitative indicators to describe the correlation. These may affect the results to some extent.*

   Our work focuses on the seismological part and less on the geological aspects, as these have been analyzed in detail by others for the Kumamoto region in context of the 2016 earthquake. Analysis of physical and mechanical properties of rock-soil mass has been conducted by several other authors (Dang et al., 2016; Song et al., 2017; Paudel et al., 2007, 2008; Sato et al., 2017) and we refer to those works accordingly. Including analyses concerning geotechnical factors at the same scale would expand the entire paper considerably, and is beyond the scope of a single publication and beyond our original objective. All metrics and methods are derived from accepted works in both geotechnical engineering and engineering seismology (e.g Harp and Wilson, 1995; Somerville et al., 1997). One of our key results—the influence of rupture directivity on landslide patterns—has been speculated about in previous studies (e.g. Hovius and Meunier, 2012). We also fail to see direct benefits of using a DEM of higher resolution and performing geotechnical analyses for the regional pattern of landsliding that we are interested in explaining. In any case, we use the DEM with highest resolution that is freely available for the region.

5. *Figure 1. Add a map scale and identify the epicenter of the Yufu event.*

   Like in the other maps, the map scale is now given in form of UTM coordinates and the event epicenter has been added.

6. *The location of mountain peaks should be shown in figure 2a. The details in the four areas listed in figure 5 should be evidenced by zooming in.*

   The mountain peaks haven been added to Fig. 2.

7. *Page 4. The map scale of the Seamless Digital Geological Map of Japan should be stated.*

   Yes, done.

   Changes in text (page 4, line 11-12):

   While data on major geological units are from the Seamless Digital Geological Map of Japan (scale 1:200,000) by the Geological Survey of Japan.

8. *Page 4. The computation process of fundamental frequency of hillslope section should be stated.*

   We do not compute the fundamental frequency; this is not necessary for the purpose of the computation of the median amplification factor (MAF). To avoid further confusion with the fundamental frequency of the hillslope, we deleted the following sentence: "The frequency f of the seismic wave is the fundamental frequency of the hillslope section on which landsliding occurred (Massa et al., 2014)." We see that this sentence might imply that MAF requires knowledge of the fundamental frequency of the hillslope. The frequency f as it used for the computation of MAF, is the frequency of the seismic wave.

9. *Page 8. Throughout the paper, no coseismic landslide displacement is calculated or used. I suggest delete this part.*

   We use the coseismic landslide displacement relation to show that it is related to acceleration and velocity, as our presented GMPE does. We clarified its purpose.

   Changes in text (in page 9 lines 7-9):

   Thus, the coseismic hillslope performance can be characterized by velocity and acceleration. In the following sections, we derive a ground-motion model based on the acceleration related Arias intensity and the velocity related radiated seismic energy.

10. *Page 11. Many empirical attenuation relationships for Arias intensity are developed recent years. Why use the Kramer (1996) model here?*

    As stated in the text, the functional form of Kramer (1996) is a template, and most ground motion prediction equations—including most recent ones—are related to it. We use the Kramer (1996) template function to highlight that our functional model does not differ from the bulk of other GMPEs. We clarified this and rewrote the first paragraph of the section related to the landslide related ground-motion models (page 13 lines 8-15).

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