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Rupture directivity of the Kumamoto 2016 Earthquake on landslide distribution

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Earthquakes severely affect the surrounding landscape, mostly tied to immediate hillslope response by landsliding. Widely accepted theory expects the spatial distribution of earthquake-triggered landslides to be governed by topography, lithology and seismic measures such as the Arias intensity. Assumptions that relate landslide distribution to the acceleration based Arias intensity which is more affected by higher frequencies, whereas energy is a velocity-derived metric, and dominated by lower frequencies. Less focus has been given to the response of landslides to directivity, frequency, and energy distribution released by strike-slip events. Here we proceed towards a more complete spatial explanation of the 1,500 landslides triggered in the aftermath of the 2016 Kumamoto earthquake (M_W 7.0) in central Kyushu (Japan). While this strike-slip event exhibits a clear NW-SE orientation, we noticed a remarkable concentration of landslides to the Northeast of the rupture zone, though similar topographic and lithological conditions exist in other locations. Our analysis of 240 seismic records revealed a strong a directivity effect in the seismic radiation pattern characterized by lower frequencies and higher amplitudes and energies in the affected region. This directivity effect triggered a spatially-bound landslide activity, both in number and slipped area, which we fail to explain with Arias intensity or MAF alone. In combination with high-resolution Digital Elevation Models, we further demonstrate that the crowns of the landslides are located in areas of steep slopes and elevated median amplification factors (MAF). In addition, we show a preferred orientation of the landslides normal to the rupture plane, which is governed by the directivity effect and not by the aspect of the topography. We conclude that directivity, frequency, and energy distribution allows better modelling of the size and location of the landslides for a strike-slip event.