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EROSION FROM EARTHQUAKE, RAINFALL AND SNOWMELT INDUCED LANDSLIDES

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In this paper, we quantify the role of landslides in erosion and in particular, the role of earthquakes to landslides to erosion. A landslide event consists of single to tens of thousands of landslides associated with a trigger, such as an earthquake, sudden snowmelt, or extended precipitation. We have previously introduced a general landslide distribution for the landslide areas associated with individual landslide events. This distribution consists of an inverse gamma distribution, a power-law frequency-area tail for medium and large landslide areas and an exponential "roll-over" for small areas. We believe that our landslide distribution does a rough quantification of the total area (and volume) of landslides that occur for landslide events of different magnitudes, and use this distribution to relate our landslide magnitude to total landslide volume. Using estimated recurrence intervals for three landslide event inventories, we have inferred regional erosion rates due to landslides for the Northridge earthquake-triggered, Umbria (Italy) snowmelt-triggered, and Guatemala heavy-rain triggered events, as 0.1, 0.4, and 2.5 yr^{-1}, respectively. Comparing historical inventories to our general landslide event distribution, we have made extrapolations and estimated total landslide volumes associated with two historical inventories in Italy and Japan. Using estimates for time intervals over which these historical landslides accumulated, the associated long-term erosion rates were found to be 1.0 mm yr^{-1} in Umbria, Italy and 2.2 mm yr^{-1} in Japan. We then use an empirical relationship between total landslide volume and earthquake magnitude to determine analytic relationships between earthquake magnitude and the associated landslide event magnitude, area and volume of the largest

landslide triggered, and total area of all landslides triggered. Using the Gutenberg–Richter frequency-magnitude relation for regional seismicity, we analytically relate the seismically-induced erosion rate to the seismic intensity and the magnitude of the largest regional earthquakes. We find that typical seismically-induced erosion rates in very active subduction zones is $\approx$ 0.2–2 mm yr^{-1} and adjacent to plate boundary strike-slip zones $\approx$ 0.01–0.2 mm yr^{-1}.