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The Statistical Distributions of Landslide Length to Width Ratios

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There has been considerable effort in analysis of the frequency-size statistics of landslide areas and volumes, yet less attention to the statistics of landslide shape. Here, we use two substantially complete triggered event landslide area inventories to quantify how length (L) to width (W) ratios vary as a function of landslide area. The first inventory is 11,111 landslides triggered by the 17 January 1994 Northridge earthquake in California and the second inventory is 9594 landslides triggered by heavy rainfall from Hurricane Mitch in Guatemala in late October and early November 1998. We assume that all landslide shapes can be abstracted to a rectangle $L \times W$, and find that the ratio of the long side (L) to the short side (W) of this shape varies with landslide area. The length-to-width ratio, L/W, is calculated by two methods which are considered separately: (i) from a quadratic equation using the given inventory landslide area and perimeter; (ii) applying a 'bounding box' where L is the longest linear axis of the landslide and W perpendicular to this. For each of the two methods, the statistical distribution using Maximum likelihood estimation of L/W values were then considered for eight landslide area categories (bins) increasing logarithmically: A_L = 100–199, 200–399, 400–799, 800–1599, 1600–3199, 3200–6399, 6400–12,799, 12,800–25,600 m^2. We find that for each landslide area bin considered, the probability density function of L/W follows reasonably well a three-parameter inverse gamma distribution; this distribution has a power-law decay with exponent (ρ + 1) for medium and large landslide areas and an exponential rollover for small areas. There is a relatively low probability of landslides where L/W = 1 (i.e. a square), with the maximum probability of occurrence for L/W = 1.8 to 2.2 for landside areas in categories 100–199, …, 3200–6399 m^2, and L/W = 3 and 7 for the two largest landslide area categories. For the three landslide area categories between 100–800 m^2, the inverse gamma distributions are broadly similar. For the next five categories, 800 to 25,600 m^2, as the landslide area category gets larger, the gradient of the left hand tail (smaller length-to-width ratios) decreases and the right hand tail (larger ratios) is a little more variable: first a decreasing gradient but then it increases again. In this paper we have found that the statistics of length-to-width ratios, when considered for different landslide area ranges, follow inverse-gamma distributions, similar to that found in the literature for the statistics of landslide areas themselves. This work will aid in analytic and computer landslides modelling, where the models need as an input a general statistical distribution of length-to-width landslide ratios.