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Landslide scaling and magnitude-frequency distribution

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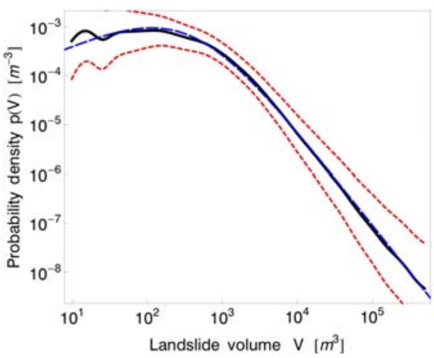
Landslide-driven erosion is controlled by the scale and frequency of slope failures and by the consequent fluxes of debris off the hillslopes. Here I focus on the magnitude-frequency part of the process and develop a theory of initial slope failure and debris mobilization that reproduces the heavy-tailed distributions (PDFs) observed for landslide source areas and volumes. Landslide rupture propagation is treated as a quasi-static, non-inertial process of simplified elastoplastic deformation with strain weakening; debris runout is not considered. The model tracks the stochastically evolving imbalance of frictional, cohesive, and body forces across a failing slope, and uses safety-factor concepts to convert the evolving imbalance into a series of incremental rupture growth or arrest probabilities. A single rupture is simulated with a sequence of weighted ``coin tosses'' with weights set by the growth probabilities. Slope failure treated in this stochastic way is a survival process that generates asymptotically power-law-tail PDFs of area and volume for rock and debris slides; predicted scaling exponents are consistent with analyses of landslide inventories. The primary control on the shape of the model PDFs is the relative importance of cohesion over friction in setting slope stability: the scaling of smaller, shallower failures, and the size of the most common landslide volumes, are the result of the low cohesion of soil and regolith, whereas the negative power-law tail scaling for larger failures is tied to the greater cohesion of bedrock. The debris budget may be dominated by small or large landslides depending on the scaling of both the PDF and of the depth-length relation. I will present new model results that confirm the hypothesis that depth-length scaling is linear.



Model PDF of landslide volumes.