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Evaluating clustered landslides volume by a digital natural terrain approach

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Intense earthquakes can trigger tens of thousands of landslides in the stricken area (e.g. 1999 Chi-Chi earthquake; 2008 Wenchuan earthquake; 2018 Hokkaido earthquake). The loose deposits of these landslides provide abundant source materials for debris flows in rainy season. Therefore, determining the deposit volume of co-seismic landslides is essential for debris flow simulation, risk assessment and risk management as well as evaluation of long-term post-earthquake hazards evolution. However, during an earthquake, co-seismic landslides occur concurrently and shelter the boundaries of each other. The overlapping in clustered co-seismic landslide boundaries makes a single landslide display much large area from satellite images interpretation, either manually or automatically. Consequently, the calculated landslide volumes are overestimated when applying landslide area-volume power laws. To solve this problem, we propose a partitioning approach of clustered landslides to find the boundaries of individual landslides, by means of generating the Flow Directions of clustered landslides from a local digital elevation model (DEM). Three severely damaged catchments in the Wenchuan earthquake region are chosen as our study area. Each clustered landslide in these catchments is partitioned into several individual landslides and then calculated by power law scaling relationship. The adopted power law scaling relationship is selected out of six widely used power laws and verified by 11 local landslide cases by random distribution matching in MATLAB. For comparison validation, the post-earthquake images displaying boundaries of individual landslides two years later are interpreted and detailed field survey results of these gullies are also deployed. The results show that the proposed approach works well in volume calculation. The calculated landslides volume is only 3% larger than that derived by the post image method and is 1.3 times of the field investigation results. Before the partitioning, the total volume of landslides is 1.97 and 2.03 times that by the post image method and field investigation, respectively. At the same time, the resulting uncertainty of this approach is controlled below 12.5%.