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Combination of landslide volumes estimation and debris flow simulation in the Xinkai village, southern Taiwan

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Many debris flows in the tropical and mountainous areas, including Taiwan, are triggered by heavy rainfall with failed materials from large landslides and usually induced severe natural hazards. To assess debris flow hazards, numerical simulation for affecting zone is widely adopted in Taiwan. As for the simulation, the estimation of triggering volume of debris flow is a critical component. Previous studies have estimated these volumes by field surveys or equilibrium concentration concept, which estimates the volume of debris flow by using accumulated rainfall. However, as shown in many studies in recent years, the volume of failed materials triggered by landslide could be more accurately estimated by empirical relationships relating the volume of individual landslides to its area. In this study, we propose a new novel methodology comprising this scaling relationship for landslide volume estimation and Debris2D, which is a numerical model and developed by Liu and Huang (2006, Computat. Geosci. 10:221-240), to simulate the flowing properties of failed materials from triggering site and assess final deposition and affected zone. To verify this methodology, the case triggered by typhoon Morakot in August 2009 in XinKai village, in southwest Taiwan is conducted. The landslide volume for debris flow is estimated by the triggering area obtained in the aerial photos after disaster together with the scaling volume-area relationship for landslide volume. From simulation results, the affected area concides with the one from aerial photos very well and the simulated deposition depth is 6 meters in average, which also approximates the result by field survey. Besides, we also present the sensitive analysis of our simulation inputs, including landslide volume, yield stress, and digital elevation model (DEM). The inputs of landslide volume and DEM are sensitive except yield stress. The over- or under-estimates of landslide volumes can lead to large uncertainties in assessing the affected area of debris flow. The methodology proposed in this study is practical and reliable for the assessment and mitigation of debris flow hazards.