Coupling a slope stability model and a fracture flow model for predicting the timing of typhoon-induced landslide

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Abstract: Many processed-based models have been proposed to access the susceptibility of rainfall-induced landslides. However, triggering hydrology of landsliding can be different between climatic and geologic regions. In Taiwan, large portion of weathered rock fragments contained in mountainous hillslope soils led to a very high conductivity over near surface, and flows within bedrock fractures can be significantly recharged by typhoon rainfalls, and trigger landslides. This hydrological mechanism has never been incorporated in a landslide model scheme. A coupled model has therefore been developed to predict the timing of shallow landslides, by integrating a transient two-layered (soil and fractured bedrock) wetness model and a slope stability model to estimate critical wetness for landslide initiation. The coupled model was first tested in an experiment site located at Hsiuluan Village in northern Taiwan. At the sites, the landslide data and timing had been investigated and recorded after a debris-flow event in 2004. The model was then applied to the 116.6 km^2 Hua-goushan Watershed in southern Taiwan, and the simulation results were validated by comparing them with a landslide inventory prepared after Typhoon Morakot (2009), including landslide locations and their timing. For watershed-level application, the model achieved an overall accuracy of 0.81 in predicting landslide location. The model also explicitly and correctly captured the time range of landslide occurrence, and performed reasonably well in predicting the timing of seven sites affected by debris flows. We conclude that the coupled model, by considering the influence of fracture flow, is suitable for predicting the location and timing of typhoon-induced landslides in Taiwan. The model can be applied to other watersheds with similar environment, assuming that reliable rainfall estimates and soil physics data are available.

Keywords: shallow landslide, landslide timing, soil wetness, typhoon, landslide hazard