TRIGRS and DEBRIS-2D in Large Scale Sediment Disaster Assessment: Applied in Daniao Tribe Watershed in Taiwan

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1 Introduction

The major uncertainty during planning of countermeasures of large-scale sediment disasters is the estimation of potential landslide volumes. In this study, we considered a large-scale sediment disaster assessment by using two numerical programs TRIGRS and DEBRIS-2D. An actually example of a large-scale sediment disaster simulation of the Daniao creek watershed in Eastern Taiwan will be demonstrated.

TRIGRS is mainly used for potential area that is prone to shallow precipitation induced landslides. The program is for computing transient pore-pressure change and the corresponding change in safety factor due to rainfall infiltration. The result could be used to calculate the initial landslide volumes under different return period of rainfall.

DEBRIS_2D is a debris flow simulation program which uses the generalized Julien and Lan (1991) rheological model. The final spread of a landslide is one of the output and has been proven to be very useful for real large-scale sediment transport. The simulated results are useful for countermeasure plans.

A field case of debris flow that occurred during Typhoon Morakot in August 2009 at the Daniao tribe watershed in Eastern Taiwan was used in this study. The Typhoon Morakot produced 740.5 mm of rainfall in 62 hours, and induced many landslides and debris flows. This paper used TRIGRS and DEBRIS_2D in a large-scale sediment disaster assessed. The hazard area is almost consistent to the field measurements.

2 Landslide and Debris flow simulation in Daniao Tribe Watershed

The Daniao tribe debris flow occurred in the debris flow potential creek DF097 in Taitung (Eastern Taiwan). Creek DF097 has a high debris flow disaster potential according to Soil and Water Conservation Bureau in Taiwan. The watershed area of DF097 is approximately 0.86 km². A total of 71.7 % of the area has slope greater than 15°, 18.6 % of the area has slope between 15° and 6°, and 28.3 % has slope less than 6°. The average creek bottom slope is 23.2 %. From the field samples, the solid density was 2.6 g/cm³, and the rest angle of solids was 30°. With the liquid density of 1.0 g/cm³, the equilibrium concentration was calculated as 41.6%.

Typhoon Morakot struck Taiwan in August 2009 and produced heavy rainfall. The maximal rainfall intensity of this event reached 45.5 mm/hr, and accumulated 759 mm of rainfall in 66 hours (from August 7, 2009 at 9:00 a.m. to August 9, 2009 at 11:00 p.m.). On August 9, 2009 at 3:00 p.m. (with a rainfall accumulation of 740.5 mm in 62 hours), the rainfall induced considerable landslides and debris flows. Field investigations after the disaster revealed that 17.2 % (0.1485 km³) of the watershed was buried, the total volume of debris flow exceeded 500,000 m³, and almost 200,000 m³ flowed out of the valley.

Since the initial volume of landslides is unknown, so TRIGRS is used for stability analysis of a Daniao tribe watershed. A relationship between a safety factor and a landslide depth is calibrated from uncertainty analysis. The potential volume of a landslide is decided with the safety factor less than 1. These results provide 565,000 m³ initial volumes for landslides and its locations.

DEBRIS-2D model was applied to assess the hazard zone with landslides volume calculated from TRIGRS. The yield stress 250 dyne/cm² was measured in the field. The computational grid size was 5mx5m. The simulation results for total volume of 565,000 m³ is shown in Fig. 1 and is nearly consistent with the field measurements. The maximal depth of the deposit is greater than 15 m. The sources of debris flows were distributed in the gap of the watershed (in the medium stream) and flowed out of the valley region (in the down stream). The maximal velocity is greater than 20 m/sec during the start of the debris flow. It began to slow rapidly when the debris flow passed the watershed gap (maximal velocity less than 3 m/sec). The results indicated that it only took 10 minutes for the debris flow to reach upstream of Daniao tribe. Although the debris flow velocity is slowed to 0.5 m/sec, the debris flow front peak continued
to maintain the same depth ($\approx 15$ m). The hazard area is almost consistent to the field measurements.

3 Concluding remarks

In this study, the TRIGRS model was applied to assess the potential amount of a volume of a landslide, due to Typhoon Morakot rainfall. TRIGS is used to provide the initial volume for debris flow simulation rather than the real field measurement. The DEBRIS-2D model was applied to assess the hazard zone using inputs from TRIGS' results. The simulated results are good. This implies that the combination of TRIGS and DEBRIS-2D can be used for prediction of future disasters and is very useful for mitigation designs.

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References


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