Changes in rainfall thresholds for debris flow initiation and run-out on the local scale in the Wenchuan earthquake area, SW China.

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•Introduction

A dramatic increase in debris flows occurred in the years after the 2008 Wenchuan Earthquake in SW China due to the deposition of loose co-seismic landslide material.(see Figure 1 and 2)

Figure 1 *The Shuida catchment with co-seismic landslides*

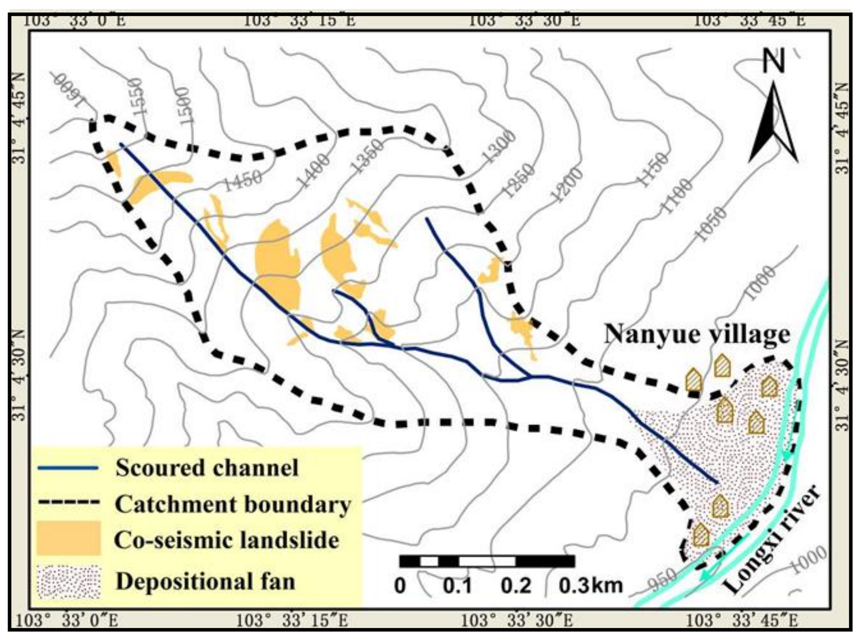

Figure 2 *Geomorphological map of the Shuida catchment with co-seismic landslides and a depositional fan caused by the August 2011 debris flows*

•Model

A preliminary integrated model is proposed here, which describes the relationship between rain input and debris flow run-out in order to establish thresholds for triggering conditions and critical run-out distances. The model integrates in a simple way rainfall, surface run –off, concentrated erosion of the loose material mostly in channels, propagation and deposition of the flow material.

•Model calibration

The model was calibrated on total volumes of debris flow materials deposited at the outlet of the Shuida catchment during two successive rain events which occurred in August 2011. (Fig 3 , 4 and Table1, 2)

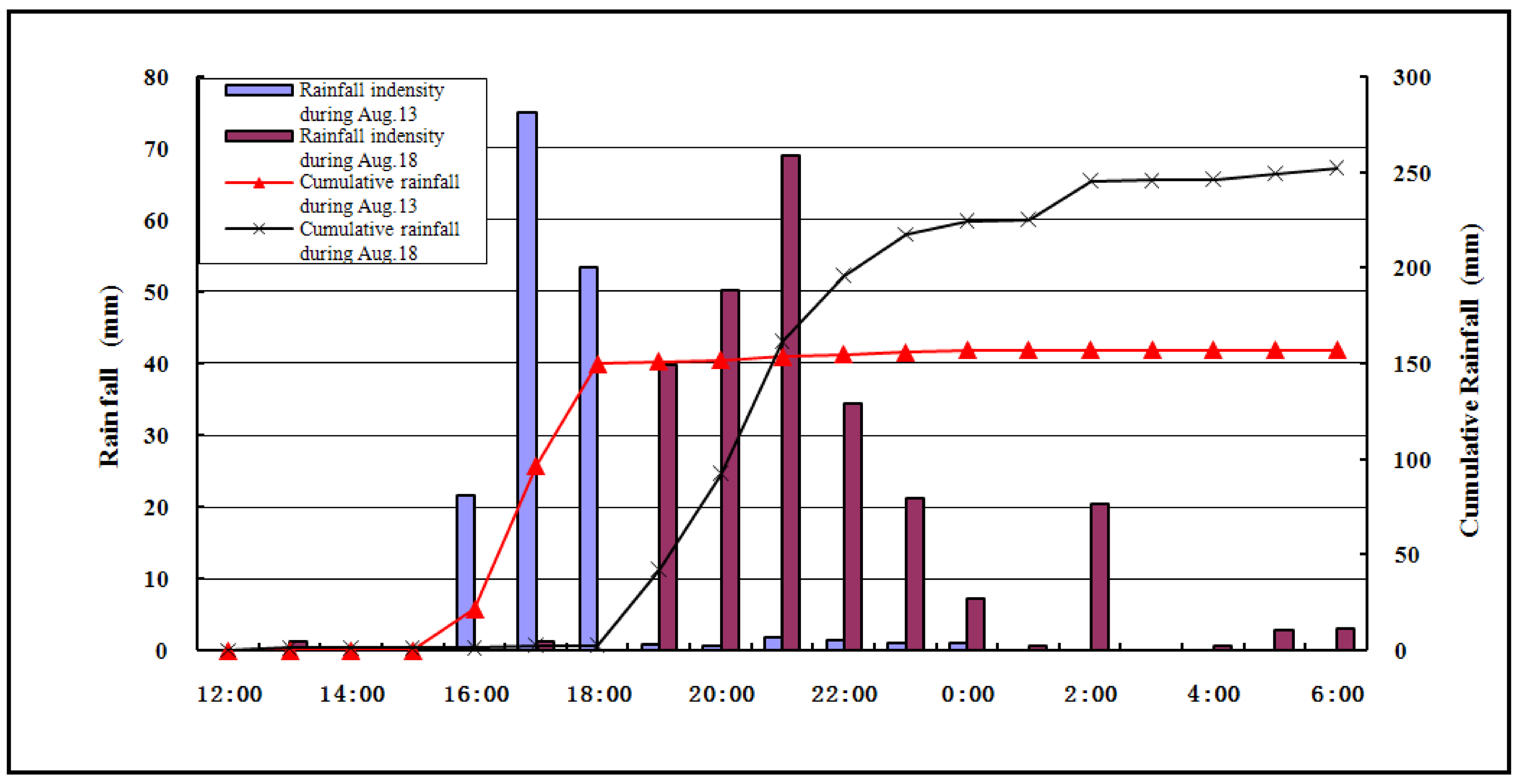

Figure 3 *Rainfall intensity (mm/hr) and cumulative rainfall (mm) for the August 13 and August 18 2011 debris flow events.(After Tang et al. 2012)*

Scenario	β (m^{-1})	Ksoil mhr^{-1}	Coh kPa	Phi (^{0})	Visc kPa s	N $m^{-1/3}$ s
Aug 13	0.0011	0.01	1	0	1	0.04
Aug 18	0.0012	0.01	1	0	1	0.04

Table 1 *Parametric values used for calibration of the model: β = erosion constant; Ksoil =effective infiltration capacity; Coh= mean yield strenght of Bingham material ; Phi =friction coefficient; Visc=dynamic viscosity;N= Manning's N*

Scenario	Observed Volume	Calculated Volume	Observed start	Calculated start	Calculated end
August 13	29000 m^3	28900 m3	16.30 hr	17.10 hr	19.10 hr
August 18	31000 m^3	30920 m3	19.30 hr	20.10 hr	21.30 hr

Table 2 *Observed and simulated debris flow volumes deposited in the Longxi River plane and estimated and observed start and end of the debris flows for the 13th and 18th of August events*

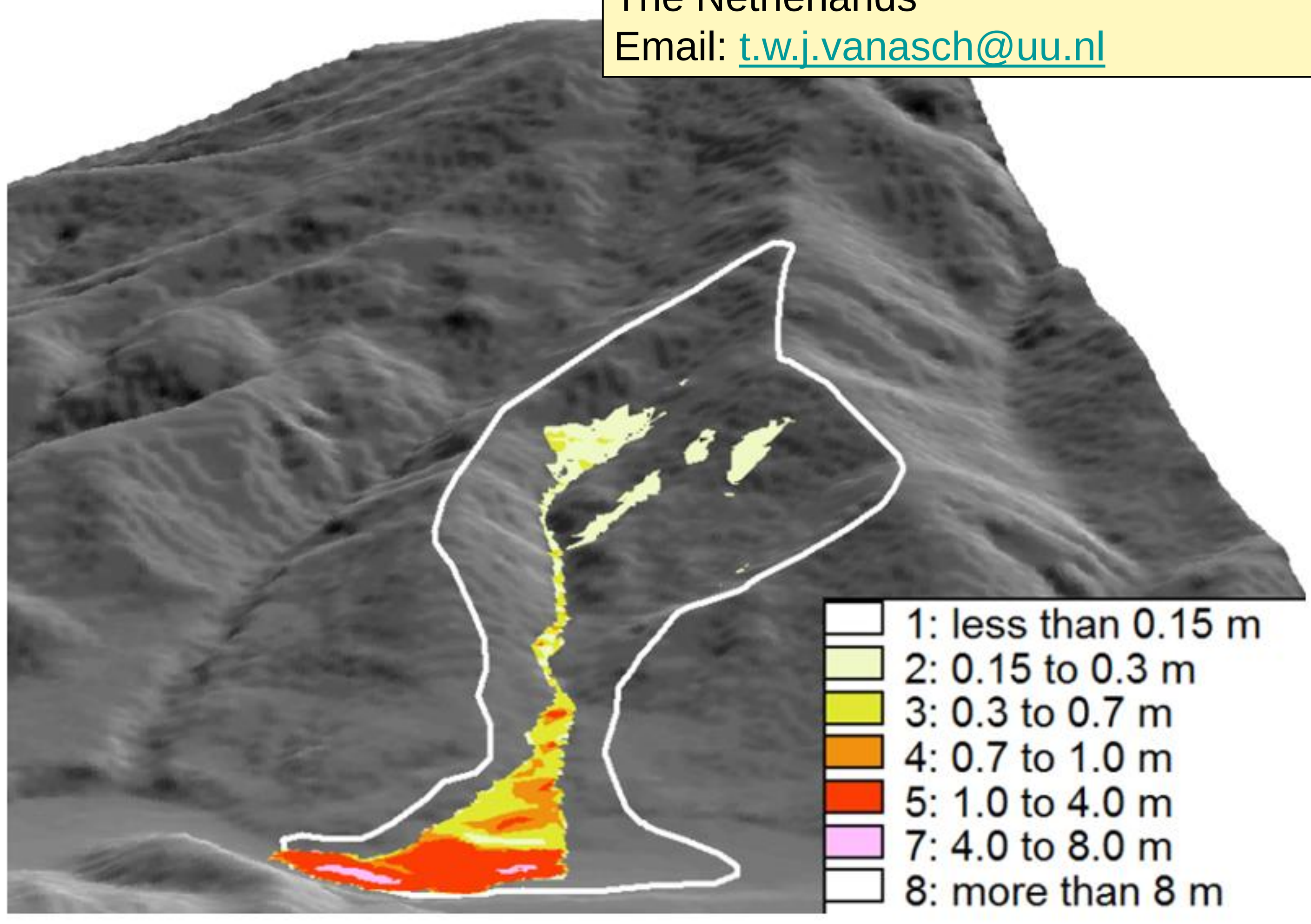

Figure 4 *Simulated debris flow deposits in the Shuida catchment after the August 13 and 18 debris flow events. The white line in the flood plane is the observed limit of spreading of the debris flow materials. (See also Fig 2.) This spreading could not be simulated quite well due to the limited resolution of the DEM*

•Rainfall thresholds

The calibrated model was used to construct critical rainfall intensity-duration graphs defining thresholds for respectively the start of debris flow development and for a critical run-out distance (just until the outlet of the catchment) *(see Fig 5)*

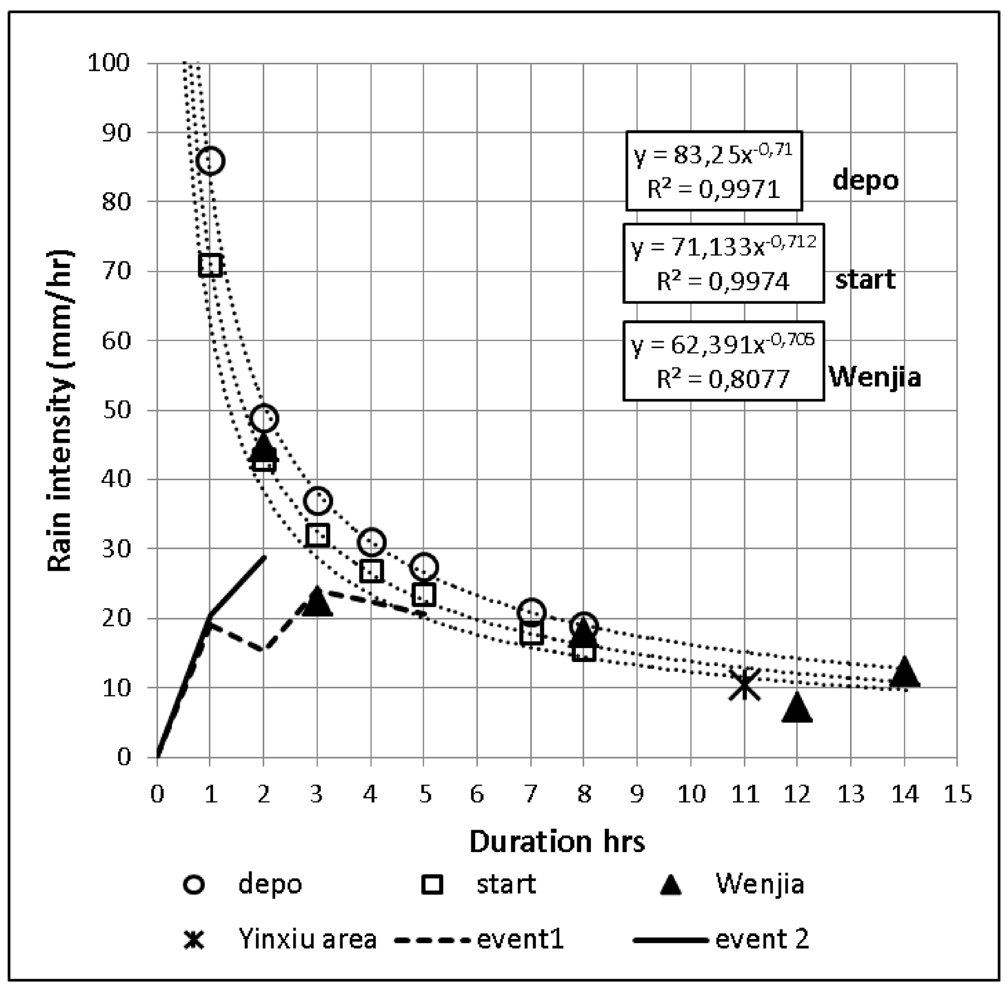

Figure 5: *Graphs showing calculated combinations of critical rain intensity (mm hr^{-1}) and duration (hrs) for the "start" and critical run-out ("depo") of debris flows in the Shuida catchment. The graphs are compared with a threshold graph for the triggering of debris flows in the Wenjia catchment which is constructed on the basis of 5 triggering rain events with different mean intensity and duration.*

In August 2012 two severe rain events were measured in the Shuida catchment, which did not produce debris flows. A plot of these rain events (See fig 5: "event 1" and "2") shows that the mean intensity over respectively 5 and 2 hours was not enough to reach the calculated threshold graphs of the Shuida catchment

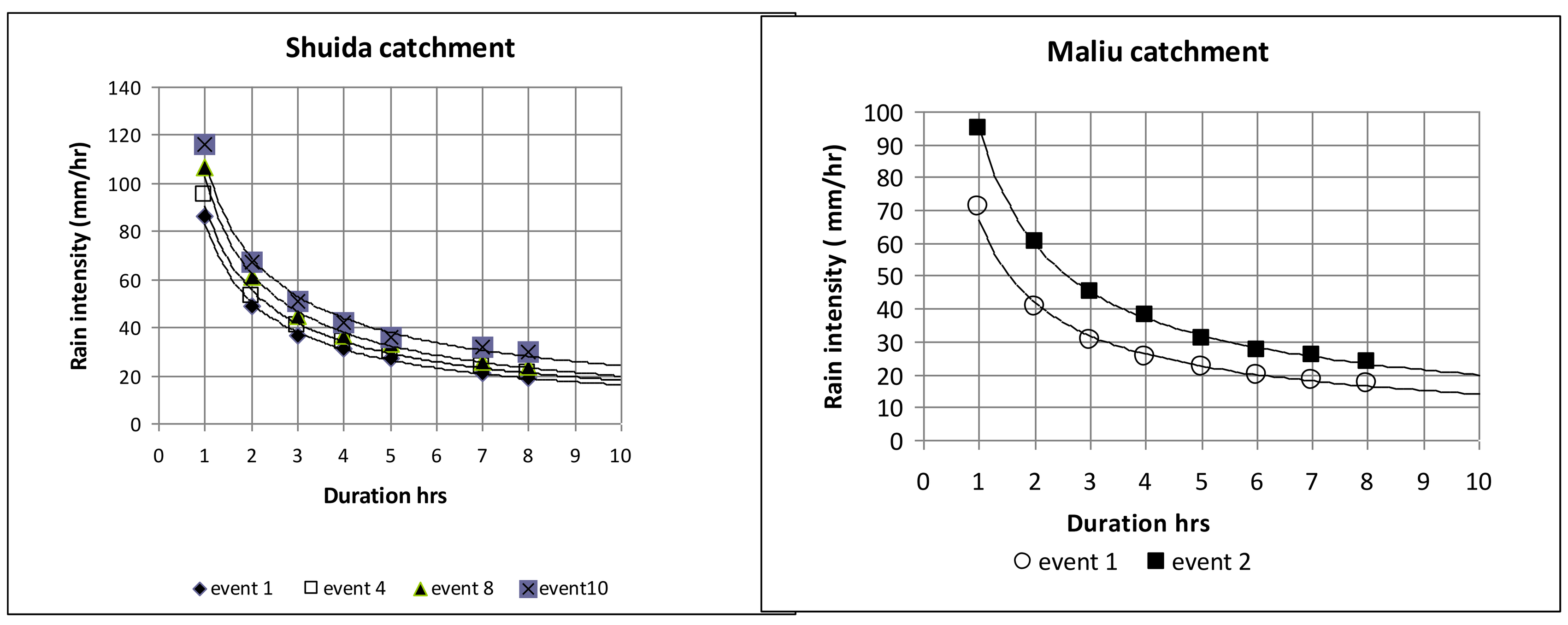

Figure 6: *Changes in the threshold graphs after respectively 1,4, 8,and 10 consecutive rain events with a certain intensity and duration for the Shuida catchment (**a**) and after 2 consecutive events for the Maliu catchment nearby (**b**) The latter shows also a larger shift of the thresols between the two consecutive events .*

•Temporal changes in rainfall thresholds and differences between catchments

Simulations of consecutive rain events with different intensities and durations were run with the model and the critical mean rain intensity to reach the outlet was determined for each model run for the Shuida catchment and the Maliu catchment nearby. Figure 6 shows a shift of the threshold curves to higher critical values for consecutive rain events. After respectively 10 (Fig 6a) and 2 (Fig. 6b) consecutive events of a certain intensity and duration the source material for debris flows in the channels was depleted.