Geophysical Research Abstracts, Vol. 8, 07639, 2006
SRef-ID: 1607-7962/gra/EGU06-A-07639

Landslide events and river sediment transport: a case study at Tsaoling, Chingshui River, Taiwan

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On September 21 1999, a catastrophic landslide occurred in the mountainous Tsaoling area in Central-Western Taiwan. This landslide was triggered by the destructive Chi-Chi earthquake (ML=7.3), at epicentral distance of about 35 km. We characterised the landslide topographic surface using a high-resolution 1-m LiDAR DEM, 2.5 years after the 1999 landslide event. Combining the LiDAR-based post-landslide analysis with field observation and pre-landslide information (Taiwan 40-m DEM, aerial photographs and topographic maps), we analysed the sliding surface and avalanche structures. We determined the volumes related to landslide and subsequent erosion at Tsaoling. The occurrence of successive landslides and related damages at Tsaoling has been documented for the past 140 years. Historical catastrophic landslides have repeatedly occurred, in 1862 and 1941 (triggered by earthquakes), 1942 and 1979 (triggered by heavy rainfalls) and 1999 (triggered by the Chi-Chi earthquake). The Tsaoling landslide region continued to be modified due to severe river erosion, especially during rainstorms. In this study, we analyzed the rapid topographical changes during the 5 years following the event, from September 1999 to July 2003, with deep incision of the landslide mass by the Chingshui River. Erosion rates have been estimated for the interval 1970-1999 at the Taiwan scale, from measurements of river suspended-sediment discharge over 150 stations. We quantify the sediment transfer in the rivers running from high mountains to the sea, and hence the erosion rate, by combining large numbers of water discharge data with smaller numbers of sediment content data. Our observations from the Chingshui River near Tsaoling indicate

that despite upstream sediment accumulation resulting from landslide damming, landslides undoubtedly facilitate erosion, because disrupted landslide masses are quickly eroded. The study of the Tsaoling landslide suggests that the probability for further major landslide events is high, which deserves consideration in terms of natural hazard mitigation. The influence of landslides caused by destructive earthquakes on erosion budgets and denudation rates will be analysed in further studies.