Nat. Hazards Earth Syst. Sci., 8, 941–960, 2008
www.nat-hazards-earth-syst-sci.net/8/941/2008/

Natural Hazards and Earth System Sciences

Statistical approach to storm event-induced landslides susceptibility

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Received: 4 April 2008 – Revised: 4 August 2008 – Accepted: 4 August 2008 – Published: 29 August 2008

Abstract. For the interpretation of the storm event-induced landslide distribution for an area, deterministic methods are frequently used, while a region's landslide susceptibility is commonly predicted via a statistical approach based upon multi-temporal landslide inventories and environmental factors. In this study we try to use an event-based landslide inventory, a set of environmental variables and a triggering factor to build a susceptibility model for a region which is solved using a multivariate statistical method. Data for shallow landslides triggered by the 2002 typhoon, Toraji, in central western Taiwan, are selected for training the susceptibility model. The maximum rainfall intensity of the storm event is found to be an effective triggering factor affecting the landslide distribution and this is used in the model. The model is built for the Kuohsing region and validated using data from the neighboring Tungshih area and a subsequent storm event – the 2004 typhoon, Mindulle, which affected both the Kuohsing and the Tungshih areas. The results show that we can accurately interpret the landslide distribution in the study area and predict the occurrence of landslides in the neighboring region in a subsequent typhoon event. The advantage of this statistical method is that neither hydrological data, strength data, failure depth, nor a long-period landslide inventory is needed as input.

1 Introduction

To study storm event-induced landslides on a regional scale, a deterministic physical-based method is commonly used which requires the employment of an infinite-slope model and a hydrological model (Okimura and Ichikawa, 1985; Dietrich et al., 1986, 1995; Keefer et al., 1987; Montgomery and Dietrich, 1994; Wu and Sidle, 1995; Montgomery et al., 1998; Terlien, 1998; Crozer, 1999; Polemic and Sdao, 1999; Iverson, 2000; Borga et al., 2002; Wilkinson et al., 2002; Crosta and Frattini, 2003; Malet et al., 2005; Baum et al., 2005; Salciarini et al., 2006; Claessens et al., 2007a, 2007b; Schmidt et al., 2008). This approach requires the strength parameters, failure depth and soil conductibility for every point in the limit-equilibrium slope stability calculation, a requirement which can cause serious problems in terms of acquisition and control of spatial variability of the variables (Hutchinson, 1995; Guzzetti et al., 1999).

In landslide susceptibility analysis (LSA), it has been most common to use a statistical approach, where landslide inventories and causative factors are utilized to build a susceptibility model for mapping or delineating areas prone to landslides. Many different methods and techniques for assessing landslide hazards have been proposed and tested. These have already been systematically compared and their advantages and limitations outlined in the literature (Carrara, 1983; Varnes, 1984; Carrara et al., 1995; Hutchinson, 1995; Mantovani et al., 1996; Aleotti and Chowdury, 1999; Chung and Fabbri, 1999; Guzzetti et al., 1999; Wang et al., 2005; Chung, 2006; van Westen et al., 2006). Most of these approaches require multi-temporal landslide inventories, so that the susceptibility model can predict landslide occurrence for a given time period (Guzzetti et al., 1999). In previous statistical models the triggering factors have seldom been emphasized.

In recent years, Dai and Lee (2003) used the rolling 24-h rainfall as an independent variable for the building of a storm-induced shallow landslide probabilistic model. Chang et al. (2007) used the maximum 3-h rainfall and rainfall duration in their logit model to model the rainfall conditions critical for triggering landslides. Dahal et al. (2008) used extreme 1-day rainfall records in their weights-of-evidence model to predict the rainfall-induced landslide hazard. It has become a trend to incorporate rainfall as an independent variable into storm event-induced landslide modeling, but this

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Published by Copernicus Publications on behalf of the European Geosciences Union.