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Characterization of typhoon rainfall and slopeland disaster in Taiwan

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Характеристика катастрофических склоновых процессов, вызываемых тайфунными дождями на Тайване

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Тайвань – остров с горным рельефом, сложным геологическим строением и высокой сейсмической активностью. В результате вероятность и масштабы катастроф, вызываемых в горных регионах обильными осадками, сопровождающими тайфуны, всегда очень велики. В последние годы были изучены пороговые значения осадков для возникновения массового схода селей и оползней с целью обоснования для создания систем раннего оповещения об опасности. В данном исследовании рассматриваются суммы осадков для каждого тайфуна с 1989 по 2005 гг. Анализ проведен для того, чтобы выявить тайфуны, которые привели к катастрофическим склоновым процессам. Анализ показал, что критическое распределение осадков различно для разных регионов страны. На основании анализа осадков, были определены пороговые значения для возникновения катастрофы. В будущем это облегчит наращивание надежной системы предупреждения в случае массового схода катастрофических оползней и селей.

Taiwan is an island with steep topography, fractured geological formations and frequent earthquake activity. As a result, the probability and scale of slopeland disasters caused by heavy rainfall accompanied by typhoons are always very large. In recent years, rainfall thresholds of debris flow initiation have been investigated to provide governmental officials with references to adopt appropriate hazard warning systems. In this study, the accumulated rainfall for the periods between issuing and lifting the sea warning for individual typhoon events from 1989 to 2005 was analysed to characterise the typhoon rainfall induced slopeland disasters. The analysis result shows that critical rainfall distribution varied for different counties. On the basis of the rainfall characterisation analysis, the rainfall threshold for triggering disaster was determined to facilitate future design of the reliable warning system for rainfall induced slopeland disaster.

1 Introduction

Three fourths of the land in Taiwan is slopeland area. Due to the high density of population and the premise of economic growth, over development of mountainous regions is unavoidable. Taiwan is located in the region with frequent typhoons and active earthquakes (World Bank, 2005). Due to the fractured geological condition, steep slope, and speedy stream flow, residents living on the mountainous area are usually threatened by slopeland

earth disasters, such as landslides and debris flows. Thus, the characterization of typhoon high intensity rainfall and the slopeland disaster are the one of important approach for early warning system to disaster reduction (Jan, 2001; Yu, 2003). In this paper, the historical slopeland earth disasters induced by typhoons and the related precipitation, geological conditions, slope gradients, slope aspects, and provincial highway systems were investigated to characterize the risk of potential disaster on slopeland in Taiwan. A lot of high risk potential zones such as mountainside regions, valleys, and alluvial plains have become residential areas (Lin, 2002). With the frequent impacts of typhoons, floods, and debris flows, thus, the whole society bears the high risk of vulnerability to natural disasters (UNDP, 2004). Unceasing slopeland catastrophes not only threat people's lives but also result in the great economic and property loss. In recent years, Taiwan government has invested abundant funds and efforts on disaster mitigation works, and has greatly promoted the disaster reduction abilities, including pre-disaster warning, emergency response, and post-disaster rehabilitation. However, in the face of the growth of disaster intensity and multi-hazard cases, Taiwan must strengthen the existing response strategies, build up effective mitigation and evacuation methods, and carry out civic education of disaster prevention so as to minimize the damage.

2 Historical slopeland disasters

Based on the database of documented slopeland disasters in National Science and Technology Center for Disaster Reduction (NCDR), there are 3570 slopeland disasters records (debris flows, landslides, collapses, and rock falls) induced by 41 typhoon and storm events from 1989 to 2005 were selected for analysis in this study (Figure 1) (Yu, 2007). To investigate the risk potential distribution in Taiwan, a series of analyses, such as administrative region based analysis, geological analysis, and geographical analysis, were conducted according to the site locations. Besides, the database was used to determine the highways affected by slopeland disasters, and to create rainfall patterns according to typhoon impacting tracks. With these analyses, it is expected to promote people's knowledge on geographical characteristics for slopeland disasters in Taiwan.

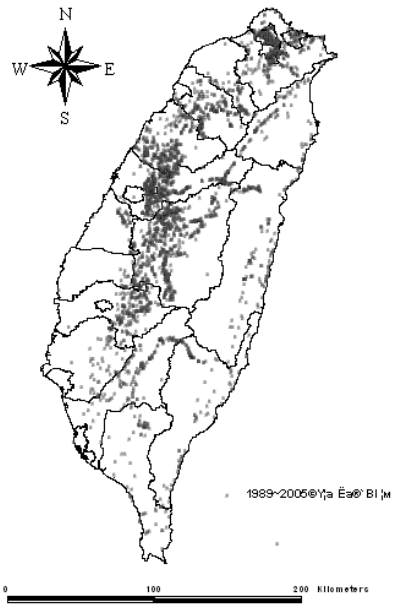

Fig. 1. Island-wide slopeland disaster sites distribution (1989-2005).

Fig. 2. Precipitation analysis related to typhoon tracks.

3 Typhoon rainfall induced slopeland disaster distribution

Based on the typhoon database of Central Weather Bureau (CWB), there were 58 typhoon events from 1989 to 2005. A series of rainfall potential analysis (200 mm, 300 mm, 400 mm and 500 mm) were conducted according to different typhoon impacting tracks 1~7. As shown in Figure 2, track 1 typhoon-induced rainfall covered the whole island besides partial regions of eastern Taiwan, and concentrated on northern mountainous areas. Track 2 typhoon-induced rainfall mainly focused on eastern and mid-southern mountainous areas. Track 3, 4 and 6 typhoon-induced rainfall concentrated on eastern areas. Track 5 typhoons brought rainfall to the southern area. Track 7 typhoon rainfall focused on northern and southern areas. This typhoon rainfall concentration potential is vital for risk evaluation of counties and townships provided that typhoon traveling track is determined.

Besides, in order to provide useful support on early warning system to prevent the typhoon rainfall from inducing slopeland disasters and thus the damage of lives and properties, the maps of critical hourly and daily rainfall isohyets were created in this study. With the reliable disaster locations, historical rainfall data, accurate disasters occurring time, and use of Inverse Distance Weighted (IDW) interpolation method, the contour maps of maximum hourly rainfall and maximum daily rainfall for disaster occurrence were created as shown in Figures 3, 4 and 5.

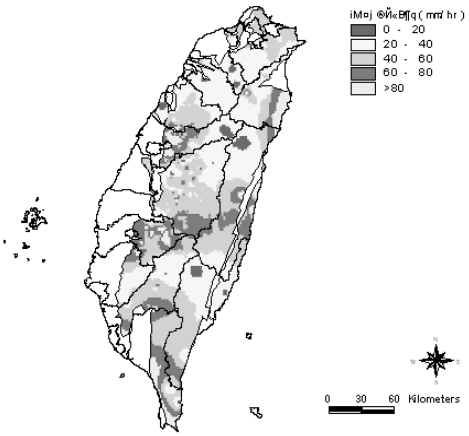

Fig. 3. Isohyet of hourly rainfall critical to slopeland disasters.

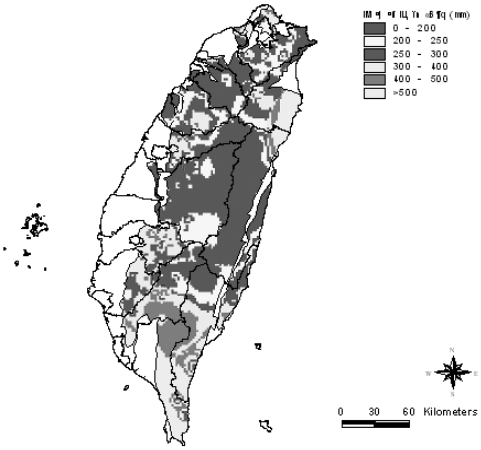

Fig. 4. Isohyet of daily rainfall critical to slopeland disasters.

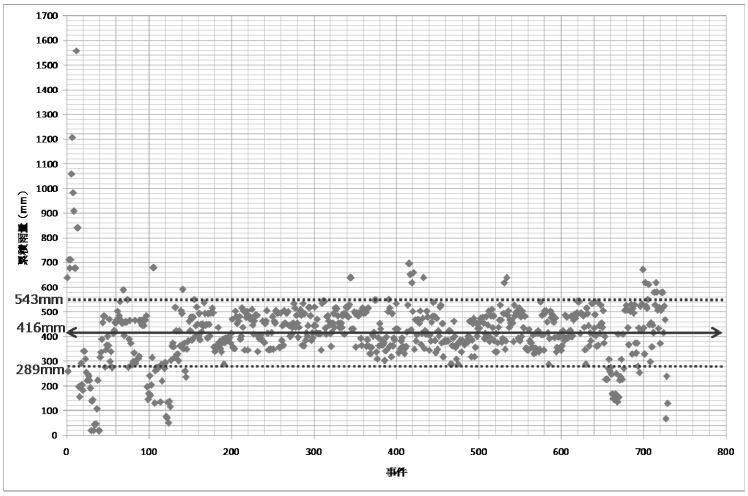

Fig. 5. Distribution of typhoon rainfall and slopeland disaster in Natou County.

4 Conclusions

Based on the typhoon rainfall induce slopeland disaster potential analyses, the regions prone to recurring disasters are subjected to the poor geological conditions and rainfall concentration. On the basis of the analysis results, it is concluded that due to the typhoon high intensity and heavy rainfall. In addition, typhoon tracks related rainfall distribution, and the isohyets of hourly and daily rainfall critical to slopeland disasters have been used in the early warning system to support commander of emergency operation center to make decisions during the typhoon storm events. In spite of the remarkable progression on the works of slopeland disaster reduction, facing the challenges of global warming and climate change, the existing technologies are never sufficient. Only if the various professional fields including meteorology, hydrology, hydraulics, engineering, and land use planning unceasingly invest their efforts, the tasks of slopeland disaster mitigation can be more successful.

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