# Towards an Auto-nowcasting System for Landslide Hazards

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## INTRODUCTION

Landslide is one of the most common and dangerous natural hazards in mountainous regions, which alone caused a total death toll of at least 32,322 in 2,626 events between 2004 and 2010 (Petley, 2012). To minimize human and material losses, landslide-related maps are widely recognized to be crucial in implementing disaster prevention and mitigation strategies (Hervas et al., 2003). With the map of landslide susceptibility, for example, various measures can be implemented to build engineering structures and plan evacuation routes. Despite of the fact that different levels of assumptions and uncertainties are associated with different approaches, the bottom line is to get a few hours of warning at least, in order to secure enough time of evacuation. This requires the nowcasting technique that provides a reliable prediction of the very near future from a large quantity of data series. This paper reports the efforts we made in the past four years to develop an auto-nowcasting system of landslide hazards, as well as the accuracy assessment of a few cases in 2015 and 2016.

## DEVELOPMENT OF MODEL

### 1. Shadow inventory and its influences on landslide susceptibility model

Landslide susceptibility describes the relative spatial likelihood for the occurrence of landslides, based on the landslide inventory prepared from space-borne or air-borne optical imagery. Most of the landslides are occurred in mountainous areas, where the imagery are acquired with some incline angles and the sun is not always in the nadir direction. Therefore, shadow is inevitable on these optical imagery. Three approaches were proposed to determine the partially-shaded topography shadow, the completed-dark topography shadow, and the cloud shadow. A standard landslide susceptibility model was used to evaluate the possible errors by neglecting the shadow inventory. Two simple approaches are also proposed to compensate the error caused by shadows.

### 2. A new region-based preparatory factor for landslide susceptibility models: the total flux

This new region-based preparatory factor, total flux (TF), takes into account the topography and hydrology conditions upstream of each gridded data cell and represents the total flux of water in the stream. The results show that TF is strongly associated with the occurrence of landslides and is a good preparatory factor for landslide susceptibility model. Using TF instead of a drainage distance factor in I-Lan region in Taiwan shows a significant improvement in accuracy in high-risk areas, which is critical for preventing and mitigating the economic and human losses due to landslides (Liu et al., 2016).

### 3. Revisit the evaluation indicators of landslide susceptibility model

The percentage of landslide occurrence (POLO) and its cumulative (CPOLO) are commonly used as indicators to measure the performance of landslide susceptibility model. To evaluate the performance of landslide prediction or issue a warning, however, requires a fixed value of threshold that cannot be determined directly from the CPOLO curve. Following the practice in weather forecast, two CPOLO curves are plotted within and outside the landslide areas, respectively, resulting in four regions of prediction: positive right, negative right, missing and false alarm. Maximizing the first two and minimize the last two regions enables us to explicitly determine a new indicator that is especially suitable for determining the threshold.

**4. Landslide susceptibility model based on geometric mean with indeterminate coefficients**

After weighting each preparatory factor by the landslide inventory, the arithmetic or geometric mean models are usually employed to calculate landslide susceptibility at each cell. But this approach implies that the contribution of each factor is the same. This restriction can be removed by introducing a set of indeterminate coefficients and searching an optimized value for each coefficient.

**5. Optimized watershed unit for enhancing the accuracy of landslide susceptibility model**

Carefully examining those problematic regions where the landslide susceptibility model does not perform well, we found that some regions are evaluated as safe but actually influenced by their fragile neighbors. By introducing the concept of optimized watershed unit, we are able to enhance the accuracy of landslide susceptibility model.

## QUANTITATING THE CONTRIBUTION OF PRECIPITATION FROM EVENT-BASED LANDSLIDE INVENTORY

To attain the goal of nowcasting landslide hazards, the contribution of trigger factor, precipitation, needs to be quantified first. Since the events of Typhoon and landslide are frequently reported in I-Lan, we are able to prepare the event-based inventory and collect the detailed precipitation record for Typhoon Saola (11 July 2012) and Typhoon Soulik (12 July 2013), respectively. In other words, the landslide hazard model is developed by using the data of Typhoon Saola (**Fig. 1a**), and validated by using the data of Typhoon Soulik (**Fig. 1b**). By implementing this model through SWCB (Soil and Water Conservation Bureau) Sediment-related Disaster Geospatial Information System (SDGIS) (http://246gis.swcb.gov.tw/) (**Fig. 1c**), we are able to provide an auto-nowcasting service with a map of five-level warning updated every hour (**Fig. 1d**).

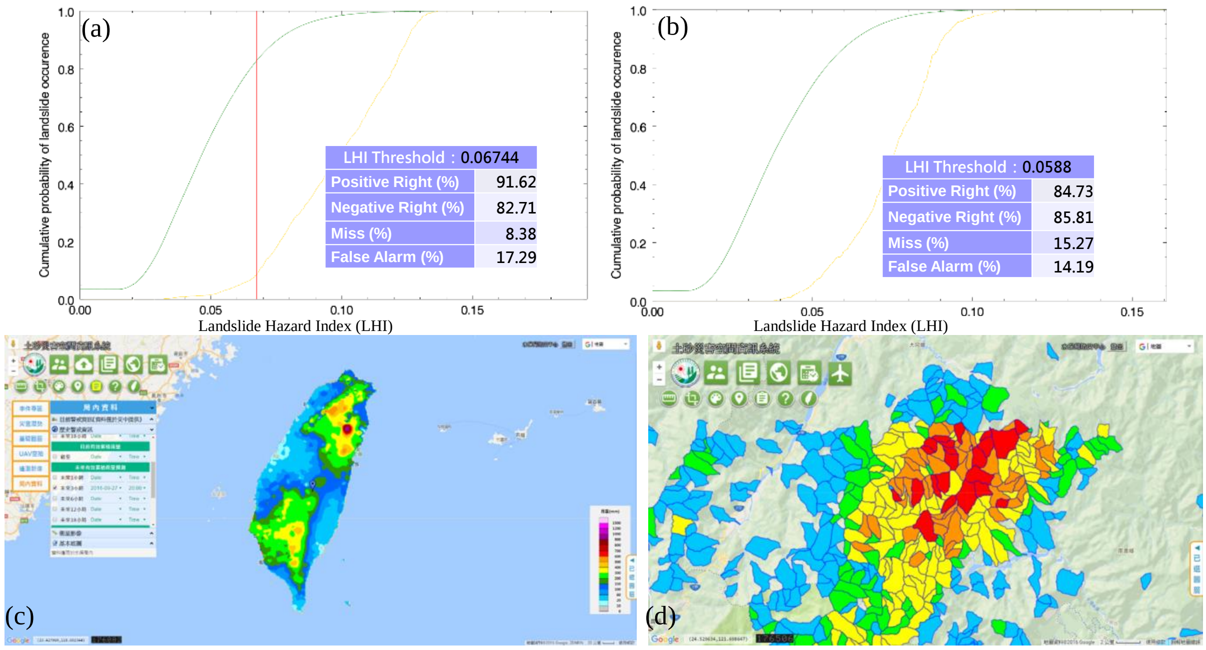


**Fig. 1** Landslide hazard model developed by using the data of (a) Typhoon Saola (11 July 2012), and validated by using the data of (b) Typhoon Soulik (12 July 2013). By implementing this model through (c) SWCB Sediment-related Disaster Geospatial Information System (SDGIS) (http://246gis.swcb.gov.tw/), we are able to provide an auto-nowcasting service with (d) a map of five-level warning updated every hour.

**Keywords:** preparatory factor, triggering factor, landslide susceptibility model, landslide inventory, nowcasting