P33

Landslide Hazard Assessment in Western Japan Using Logistic Regression Analysis with Hydrometeorological Factors

○Ying-Hsin WU, Eiichi NAKAKITA

In the last two years, under front's influence heavy rainfall occurred in Kyushu and Chugoku regions to trigger a great number of inundation and landslide disasters and to cause numerous fatalities and property damages. To achieve disaster prevention, in the real practice of early warning of landslide and debris flow hazards, the governmental authorities, i.e., JMA and MLIT, assess hazard occurrence using the soil-water index and hourly cumulated rainfall as long and short-term hydrometeorological factors (Osanai et al., 2010). The conventional methodology is effective for assessing hazard occurrence by judging the temporal snake line on a phase plane of soil-water index and hourly cumulated rainfall with critical lines calibrated by past events with the radial basis function network. However, the original assessment is based on a coarser spatial resolution (1 by 1 km) without any probability information. To improve the capability of landslide prediction, this study aims to develop a linear logistic regression model (Menard, 2001) using the same rainfall indices obtained from high-resolution XRAIN observation and an additional categorical variable of lithology type. The main advantages are that the high-resolution XRAIN observation can improve higher resolution prediction, and the logistic regression model provides informative probability further interpreting the relation between landslide and geological property. Finally, the calibrated model is then used to assess the landslide disasters occurred in Hiroshima prefecture in early July in 2018.

Data and processing

Because the high-resolution XRAIN composite observation (250 by 250 m in one minute) is available only from 2012, we extracted 727 landslide events occurred in Shimane, Yamaguchi, and Hiroshima prefectures in from 2012 to 2014 for calibrating our logistic regression model. Figure 1 illustrates the distributions of occurrence events and the random nonoccurrence events. We downloaded the datasets observed by Nogaibara and Oshio radar stations (DIAS, 2019). For each disaster event, the corresponding soil-water index and hourly cumulated rainfall was calculated five days before the occurrence in the spatial resolution of 250 by 250m. Then, at occurrence timing, the soil-water index and hourly cumulated rainfall are then extracted for regression analysis, as is shown in Fig. 2a.

Logistic regression model

Our linear logistic regression model considers three variables, i.e., hourly cumulated rainfall (Rain), soil water index (SWI), and lithology type (GEO) extracted from the official geological map published by Geological Survey of Japan. The logit function $\mathrm{logit}(Y)$ and probability function P read

$$\mathrm{logit}(Y) = \beta_0 + \beta_1(\mathrm{Rain}) + \beta_2(\mathrm{SWI}) + (\mathrm{GEO}), \quad (1)$$

$$P = 1/(1+e^{-Y}), \quad (2)$$

where β_0 to β_2 are parameters to calibrate, and GEO is a categorical variable representing different lithological type. 75% of the datasets are used for calibration, and the rest for accuracy test. The test shows the accurate ratio of prediction reaches 0.88, and the area under the receiver operating characteristic

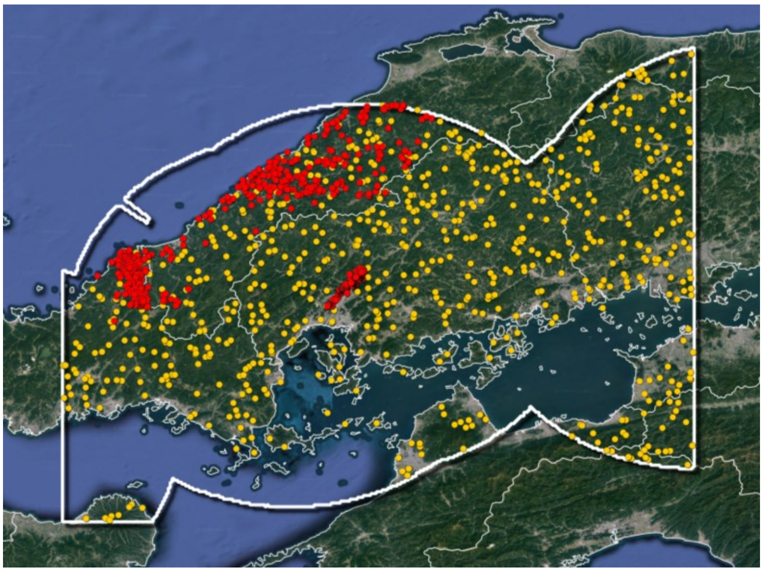

Fig. 1 Range of XRAIN observation (thick white line). Sample distributions of landslide occurrence (red circles, 727 events) and non-occurrence (golden circles) for linear logistic regression analysis. (Satellite photo source: google)

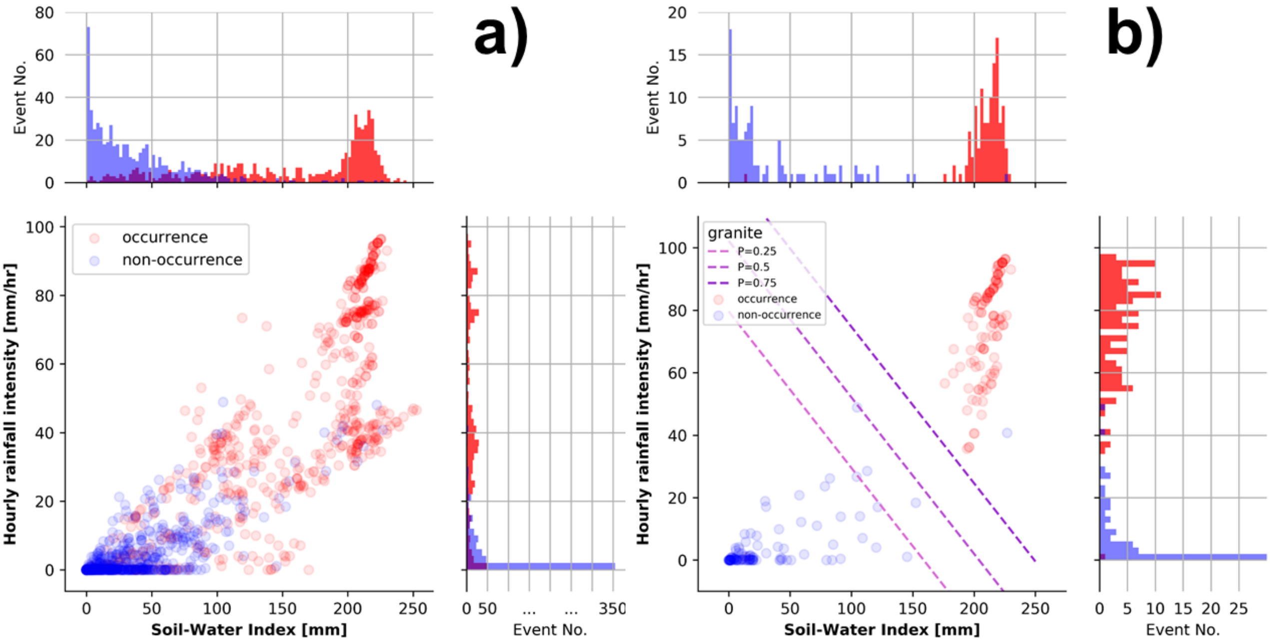

Fig. 2 Sample spaces and histograms of a) all events (1454) and b) events occurred on the area in the lithology of granite. Red and blue circles denote occurrence and non-occurrence. Purple lines denote hyperplane boundaries

curve (ROC curve) is 0.95. The validation proves the accuracy and applicability of our model. For one example, our model sharply discriminates occurrence in the area composed of granite. Figure 2b shows the hyperplanes for probabilities of 0.25, 0.5, and 0.75.

Expected results and future plans

With the calibrated logistic regression landslide model, the work aims to analyze the landslide disasters occurred in West Japan during the severe heavy rainfall event in early July in 2018. For the future research plans, we would like to provide a more informative and reliable critical line information with probability for advancing landslide disaster early warning techniques, and, meanwhile, to assess the future hazardous tendency under climate change.

References

Osanai, N., et al. (2010). *Landslide* 7, 325-338.
Menard, S. (2001). *Applied Logistic Regression Analysis*, Sage publication.
DIAS. (2019). http://www.diasjp.net/service/xrain-data/