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Spatio-temporal probability prediction of rainfall-induced landslides based on deep learning under climate change

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In recent years, with the frequent occurrence of extreme climate, rainfall-induced landslide (RIL) has become one of the main geological hazards that endanger human life and property safety. Understanding the relationship between meteorological factors and RIL is essential for promoting safety. Although the research community has been studying the spatial or temporal probability relationship between climate variability and RIL using quantitative and qualitative methods at different spatial or temporal scales for decades, the spatio-temporal probability of synchronous hazard prediction has rarely been studied. Here, we constructed a hybrid model of Convolutional Neural Network (CNN) and Long-Short Term Memory (LSTM) and utilized the spatial feature extraction capability of the CNN model and the temporal feature extraction capability of the LSTM model to infer the causal relationship of RIL and simulate the risk of RIL from the meteorological data from 1980 to 2015. In this study, the Wanzhou District of Chongqing, China was used as the research area to train and test the model, in order to provide a new idea to synchronously predict the spatial probability and temporal probability of RIL. Our results reveal that the spatio-temporal probability prediction model has higher prediction accuracy than the single spatial probability or temporal probability prediction model, and it is more consistent with the actual occurrence of RIL. The predicted results of our model show that the occurrence of RIL is mainly affected by the geological environment, followed by the intensity and duration of rainfall in extreme climates. The inferred patterns show that precipitation extremes are associated with an increased risk of RIL. Therefore, in addition to understanding the geological factors that trigger the hazards themselves, a better understanding of climate-hazard linkages enhances the spatio-temporal modeling capacity for the risk of RIL. In the future, it can be used to analyze the world's risks of RIL caused by climate change.