Detecting microearthquakes with template matching and deep learning around the 2009 Typhoon Morakot in Taiwan

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Recent studies have shown that earthquakes could be triggered by long-term surface or atmospheric loading and unloading processes. However, it is not clear that short-term fluctuations (such as the passage of extreme weather events) can also change subsurface stress conditions and trigger seismic events. Typhoon Morakot was a super wet typhoon in early August 2009, pouring 2855-mm of rain within 100 hours, which triggered more than 20,000 landslides and was followed by several moderate size earthquakes (6<M<7) in the next year. Here we investigate a potential triggering relationship between the 2009 Typhoon Morakot and earthquakes in Taiwan. Taiwan is an ideal region for studying such cascading hazards, due to frequent tropical typhoons and seismic activities. In addition, it has dense seismic networks. To achieve our scientific goal, we need to analyze a local earthquake catalog that is complete to the smallest magnitude range possible. However, the standard catalog from the Central Weather Bureau (CWB) is only complete to magnitude ~2, and hence many smaller magnitude events are not identified, especially during large aftershock sequences or extreme weather events. In this study, we use template matching and deep learning methods to search for hidden earthquakes around 2009 Typhoon Morakot in Taiwan. Our earthquake detection is based on the continuous recording of 71 local short-period stations from the CWB Seismic Network. We use 31508 CWB catalog events as templates to scan the continuous waveforms between seven months before and twelve months after this typhoon with the template matching method. As a result, we obtained a new catalog with more complete listing of microseismic events. Our preliminary results show that the new catalog has at least 3 times more than listed in the standard CWB catalog. We also trained a convolutional neural network (CNN) model for earthquake detection and phase picking with the same dataset in Taiwan. The final training accuracy is above 96%. We plan to applying this model on continuous recordings to detect hidden earthquakes during Typhoon Morakot. The earthquake detection results from both template matching and deep learning will be helpful to study the potential triggering relationship between typhoon and earthquakes.

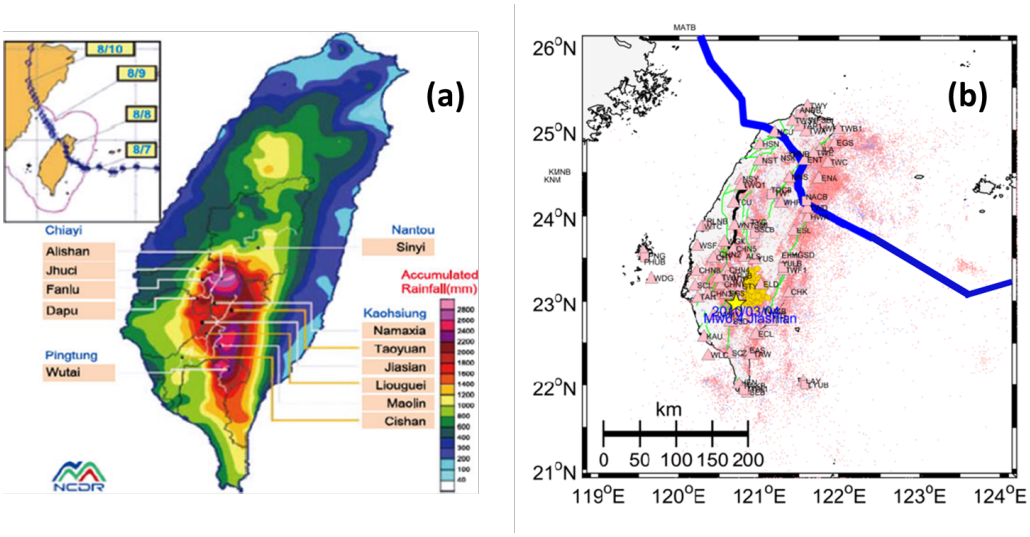

Figure 1. (a) The path of Typhoon Morakot and the distribution of total accumulated rainfall from 6 August to 10 August (Credit: Taiwan Environment Protection Administration). (b) CWB seismic stations and earthquakes in Taiwan, the blue line is the path of Typhoon Morakot.