EGU2020-3696
https://doi.org/10.5194/egusphere-egu2020-3696
EGU General Assembly 2020

A LSTM Neural Network for On-site Earthquake Early Warning

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On-site Earthquake Early Warning (EEW) systems estimate possible destructive S-waves based on initial P-waves and issue warnings before large shaking arrives. On-site EEW plays a crucial role to fill up the “blind zone” of regional EEW systems near the epicenter, which often suffers from the most disastrous ground shaking. Previous studies show that peak P-wave displacement amplitude (Pd) may provide a possible indicator of destructive earthquakes. However, the attempt to use a single indicator with fixed thresholds suffers from inevitable misfits, since the diversity in travel paths and site effects for different stations introduce complex nonlinearities. To overcome the above problem, we present a deep learning approach using Long-Short Term Memory (LSTM) neural networks. By utilizing the properties of multi-layered LSTM, we are able to train a highly non-linear neural network that takes initial waveform as input and gives an alert probability as the output on every time step. It is then tested with several major earthquake events, giving the results of a missed alarm rate less than 0.03 percent and false alarm rate less than 15 percent. Our model shows promising outcomes in reducing both missed alarms and false alarms while also providing an improving warning time for hazard mitigation procedures.