Foreshock Discrimination and Short-Term Mainshock Forecast Based on Magnitude Differences and Spatio–Temporal Distances

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Foreshocks are promising clues for short-term forecasting of large mainshocks. We propose a probabilistic discrimination model of foreshock activities to predict mainshocks. Using the single-link clustering method, the model updates the expanding seismic clusters and determines in real time the probabilities that larger subsequent events will occur. The foreshock clusters and other cluster types show different trends of certain feature statistics with respect to their magnitudes and spatio-temporal distances. Based on those features and the epicentral location, a non-linear logistic regression model is used to evaluate the probabilities that growing seismic clusters will be foreshocks triggering the mainshock within 30 days. The log of odds ratio is estimated between the foreshock clusters and other clusters for respective feature values as nonlinear spline functions from a Japanese hypocenter catalog of 1926 to 1999. From the estimated odds functions, foreshock clusters tend to have smaller differences in their two largest magnitudes, shorter time durations, and slightly longer epicentral distances within the individual clusters. Given a potential foreshock cluster, its mainshock magnitude can be predicted by the Gutenberg-Richter law over the largest foreshock magnitude. The predictive performance of our model is validated by a Japanese hypocenter catalog of 2000 to date and is not used in the parameter inference. The evaluated foreshock probabilities are roughly consistent with the actual portion of foreshocks in the validation catalog and may be used as an alert of large mainshocks.

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