



Machine learning approach for constraining the plausible ranges of frictional parameters on the Philippine Sea plate reproducing the historical sequences of the Nankai megaquakes

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The Philippine Sea plate subducting along the Nankai trough in southwest Japan has repeatedly produced megaquakes. The next megaquake is anticipated to occur in the early half of this century, causing the great West Japan disaster. Based on rate and state friction laws, several studies have successfully simulated the historical sequences of the Nankai megaquakes by adjusting frictional properties on the plate interface based on geoscience studies, e.g., depth-dependent friction properties and rupture segmentations. However, they have not succeeded in reproducing the large variations of recurrence intervals from 90 to 200 years and the time differences between ruptures of the eastern and western segments from zero to 2 years.

In this study, we explore possibilities to constrain the range of friction parameters from the data of the historical sequence of the megaquakes. To this purpose, we introduce an approximated inverse function which could predict friction parameters given an input of a sequence of quakes. Due to the interaction between sub-regions on the plate, the sequence of quakes largely varies with small variation in friction parameters at each sub-region. Thus, a fine-grained approximation of the inverse function would be required, e.g., to predict friction parameters in the level of the fourth or fifth decimal place, if effective pressure is assumed. However, building such a fine-grained prediction model would be a challenging task in machine learning fields, even using recent advanced deep learning methods. To realize such a fine-grained prediction, we propose a new deep learning method called *Magnified-View Regression* (MVR) which consists of MagnifyNet and RefineNet—MagnifyNet selects a partial range of target variables, i.e., friction parameters, and magnifies its range to a wider range. Then, RefineNet performs the regression of the target variables in the magnified range.

To evaluate the performance of our proposed method, MVR, we use a Nankai trough simulator. Since deep learning methods usually require a large number of data, we adopt a discreet cell model, in which we divide the interface into 8 large cells corresponding to rupture segments: 5 cells for Tokai, Tonankai and Nankai segments, and 2 Kanto and 1 Hyuganada cells. Then, training data are collected from each of adjacent 3 cells and the inverse function for predicting friction parameters of 5 cells (corresponding to Tokai, Tonankai and Nankai) is approximated by using deep learning methods. Using this simulated experiments and fixed values of a , L , and effective pressure, we show that our MVR can much more precisely predict a friction parameter b at each cell in the level of the fourth decimal place, in comparison with ordinary deep-learning methods. In addition, we show that the predicted parameters can reproduce simulated sequences of quakes with about 40-year recurrence interval errors.