Focal mechanism determination of inland microearthquakes in Japan based on P-wave first-motion polarities picked by neural network model

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Focal mechanism is one of earthquake source parameters that characterizes the fault geometry and the slip direction, which also implies the seismogenic stress field. In many areas in the world, focal mechanisms are routinely estimated only for earthquakes larger than a certain magnitude, such as M 3 in local cases. For better estimation of the crustal stress field, we desire a much richer focal mechanism catalog. The focal mechanism determination requires us to pick P-wave first-motion polarity, which is usually done manually and therefore time-consuming.

In this study, we construct a neural network model, whose input is three-dimensional seismogram and output is the P-wave first-motion polarity. We adopt a simple convolution network as done by prior studies (Ross et al., 2018; Hara et al., 2019). We used NIED Hi-net seismograms with P-wave arrival times in the JMA Unified Earthquake catalog. The seismograms were highpass-filtered at 1 Hz to and clipped at a certain level. By flipping the vertical component and rotating horizontal components, we augmented the data. We also prepared models with three, four, and five convolution layers followed by two fully connected layers. The clipping level, the number of the data augmentation, and the number of convolution layers are chosen according to their performance to a test dataset. ~ 280 k of seismograms are used for the training.

Finally, we applied the trained model to ~180 M of seismograms from ~110 k of inland microearthquakes with depths smaller than 20 km in Japan. We succeeded in determining the focal mechanisms of more than 99 % of the earthquakes.