

## Estimation of P-wave arrival time differences using P-wave first motion similarity with sampling frequency of 10 kHz

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In the Western Nagano Prefecture, central Japan, seismic observations with a sampling frequency of 10 kHz have been conducted since June 1995. The seismic stations are located mainly in the eastern part of the aftershock area of the 1984 Western Nagano Prefecture Earthquake, and seismic activity has been high around this area since August 1976. In this area, many earthquakes have shallow focal depths and then large signals can be observed immediately above their hypocenters. Inelastic attenuation is small probably due to homogeneous hard rocks, and the surroundings of the stations are quiet and have low noise levels, so the environment in the area is very suitable for seismic observations. Therefore, we can obtain a large number of microearthquake data and simple waveforms. In addition, the observation with a sampling frequency of 250 Hz of the Manten system has been performed since August 2008.

In this study, we defined mainshocks and their foreshocks of small to moderate earthquakes spatiotemporally based on magnitudes, origin times, and distances between hypocenters. Then, we estimated P-wave arrival time differences of the earthquakes by cross-correlating their P-wave onset waveforms.

We use the vertical component of velocity waveforms. In some spatiotemporally defined foreshock activities, there were many earthquakes that were not similar in the whole waveform but similar in the P-wave initial rise recorded at an identical station. Therefore, we calculated the time differences that maximize cross-correlation coefficients of each pair of earthquakes in a series of foreshock activities, using only windows of a length of 0.01s around P-wave onsets. We treated such time differences as P-wave arrival time differences between two earthquakes at each station. Using these time differences, we will perform relative hypocenter determination with a few meters precision and elucidate the nucleation process of a series of foreshocks which is illustrated by preslip model or cascade model.

Keywords: 10 kHz waveform, cross-correlation, relative hypocenter determination, foreshock