

Objective matched-filter analysis for detecting small events

Shiro Hirano¹, Yutaka Toyomoto¹, Hironori Kawakata¹, and Issei Doi²

1. Ritsumeikan Univ., Shiga, Japan

2. DPRI, Kyoto, Japan

abstract:

For some major earthquakes, small foreshocks can be detected via Matched-Filter (MF) analyses, which enables us to extract seismic signals from continuous noisy waveforms. In a traditional MF technique, a normalized Cross-correlation Coefficient (CC) between the continuous and template waveforms was calculated, and parts of the continuous waveform where CC with the template exceeds a threshold value have been regarded as the seismic signals. In this procedure, however, choice of the threshold is subjective, and misdetection could occur with an inappropriate threshold value.

In this study, we focus on the foreshock activity prior to an M6 earthquake in Nagano, Japan, and investigate long-term empirical frequency distributions of CC. We reveal that tails of the distributions are obviously fatter than those of Gaussian in many cases, which means that possibility of misdetection increases ten- or hundred-fold if the normal distribution is implicitly assumed. Consequently, we find that the maximum value of CC for every few seconds follows the exponential distribution with a few outliers. Furthermore, we propose an objective and threshold-free method to detect the outliers (i.e., foreshock events) from the histogram of the maximum value based on the curve fitting and AIC.