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Automatic Earthquake Locating by Stacking Characteristic Functions in a Source Scanning Method

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Exact source locating for microseismic events helps us understand subsurface structures, monitor volcanic activities and assess earthquake hazards. Conventionally, the locating problem can be solved by picking phase arrivals. However, for microseismicity which contains large numbers of low-magnitude events, phase picking is often difficult and time-consuming. In this research, we use an improved waveform-based method to locate microseismic events without phase picking. We use the Source Scanning Algorithm (SSA) to stack the Characteristic Functions (CFs) in time and space, where the maximum stack gives the best estimate of the event origin time and source location. This approach allows us to locate the event automatically by evaluating waveform coherency in terms of changes in amplitude and polarization. We conduct synthetic test using the geometry of the SIL network in Reykjane Peninsula, SW Iceland. The results show that we can locate the synthetic source with error <1km, <0.1s when the noise amplitude is less than the amplitude of the target phase. In addition, stacking CFs that evaluate changes in amplitudes gives more stable results at all noise level, while stacking CFs that consider changes in polarization gives more stable results when the noise varies with frequency. We also conduct field data test using 215 microseismic events (M<2) occurred during Aug 2010 and Mar 2011 recorded by the same network. Our results show that stacking CFs that considers changes in amplitudes gives the closest results to the manually picking method, while stacking a combined version of CF rejects more outliers. In summary, stacking CFs in the SSA provides us with the ability to consider different waveform characteristics and improved noise-robustness in source locating problems. This improved automatic waveform-based procedure offers reliable solutions to large data set with low SNR, which are typical for microseismic events, and help reduce human intervention.