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Methods of screening for cross-correlation identification of antropogenic seismic events

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Identification of antropogenic seismic events plays a big role in a number of applied seismology such as monitor of nuclear tests and quarry blasts. In recent years methods of detection and identification of antropogenic seismic signals, based on cross-correlation of templates (master events) and source records, have become increasingly widespread.
A distinctive feature of a number of multi-channel cross-correlation methods is the need for additional verification (screening) of detected events. Screening allows to filter out events that were caused by other sources and noise, even though they have high correlation value with master events. In other words, screening can reduce the probability of false alarm and increase the probability of correct detection. Screening can be accomplished a few ways, for example, by polarization analysis (for three-component signals) or by F-K analysis (for signals of seismic arrays).
We developed a screening method for multichannel seismic monitoring systems based on post-processing of waveforms cross-correlation traces. Multichannel systems are understood to mean seismic arrays and three-component stations (both velocimetric and accelerometric).
The main features of proposed method are as follows. First, for each of the seismic recording channels, including orthogonal channels of the three-component station or vertical channels of the seismic group, own samples (master events) with a high degree of specificity are used. In other words, the signals of these samples have a high value of the bandwidth-duration product of the signal. Secondly, for each of the set of master events, the calculation of cross-correlation traces is performed. Then product of cross-correlation traces and sum of cross-correlation traces are calculated. A decision of identification is made on the post-processing of product of cross-correlation traces and sum of cross-correlation traces. Proposed algorithm of decision also can recognize impossibility of cross-correlation identification In some cases.
The proposed method is well suited for automation. For its implementation, cross-platform software was developed in Python programming language using the ObsPy library.
The first results of the application of our method were obtained on a sample of three-component records of quarry blasts conducted on the territory of the East European Platform and registered by the Mikhnevo seismic array of the Institute of Geosphere Dynamics of the Russian Academy of Sciences (Moscow Region, Russia). A bank of master events was used containing 12 three-component sets, and a bank of records containing several dozens of events. Only 60% of the events were allowed to the cross-correlation identification procedure. For these events, the correct identification was achieved in all cases. The rest 40% were classified as events with unknown source.
Thus, the first results of applying our method show a good suppression of incorrect detection. At the same time, an additional research will be required to reduce the number of events classified as events with an unknown source. The implementation of this method to the records of all vertical channels of the Mikhnevo seismic array is also currently being developed.