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Detection and location of repeated events using waveform cross correlation and the Principal Component Analysis: quarry blasts at Jordan phosphate mine

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We analyzed an extensive set of signals measured by 3-C stations HRFI, PRNI, and EIL from repeated blasts at a phosphate mine in Jordan. For a given station, all available blasts were used as master events, i.e. as waveform templates, and then as slave events, i.e. sought signals, in waveform cross correlation (WCC) processing. The number of signals is more than 1000 at each station. To find the best parameters for a standard STA/LTA detector, which was applied to the resulting traces of cross correlation coefficient (CC), we used varying number of components: all 3 components or Z-component only; template lengths from 5 s to 40 s; and a set of octave filters from 1 Hz to 16 Hz. Three stations are situated in approximately the same direction from the phosphate quarry and have the same sampling rate. We cross- correlated signals obtained at different stations and found an unusually high level of similarity, which is close to the level of similarity between signals at one station. A Principle Component Analysis was also applied to the whole set of signals at each station through the Singular Value Decomposition (SVD) technique. The level of normalized eigenvalues falls to 0.2 and below for the first five to ten components. Several PCA eigenvectors, which are used as waveform templates, from the first ten were able to find all signals at CC-traces, when the WCC method was applied. Therefore, one can use a few principal components for comprehensive signal detection. Using the signals at three stations from the same events, we applied the method of relative location based on the difference of arrival times relative to a preselected set of master events. The original signals and the templates obtained with the SVD were both used for the relative location. To improve the accuracy of location one should extend the set of stations to provide a much better azimuthal coverage.