Detection and Identification of low-magnitude Seismic Events Near Bala, Central Turkey

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CTBT: Science & Technology 2011, Vienna, Austria

Published in Seismological Research Letters; January/February 2011; v. 82 no. 1; p. 97-103; DOI: 10.1785/gssrl.82.1.97

Abstract

Keskin Array located in the north of the well-known North Anatolian Fault System (NAFS) and on the south-southwest is bounded by the East Anatolian Fault System (EAFS) (Şenel et al., 1979). The central area does not have major faults and escapes to awareness as a whole which contains internal deformations (Bengil and Yilmaz, 2008). This region is not considered as seismically active but moderate-size Bala earthquakes occurred near the Tuz Golu fault might be the indicator for a future seismic activity.

Central Anatolia is bounded in the north by the well-known North Anatolian Fault System (NAFS) and on the south-southwest is bounded by the East Anatolian Fault System (EAFS) (Şenel et al., 1979). The central area does not have major faults and escapes to awareness as a whole which contains internal deformations (Bengil and Yilmaz, 2008). This region is not considered as seismically active but moderate-size Bala earthquakes occurred near the Tuz Golu fault might be the indicator for a future seismic activity.

Application of Array-Based Waveform Correlation and Standard Array Processing (STALTA) Methods for Detection of Bala Earthquake Aftershocks

For this study, a waveform correlation detector was prepared using a signal template the 27 December event that occurred at origin time 17:56.12 and has a magnitude of ML = 4.0 (Figure 3). The selected master waveform for each site consists of 60 s of data beginning at the predicted P arrival for the given master event. The same time window was cut for each channel, small time differences of the first arrivals at different sites were neglected.

The value of the correlation coefficient is not necessarily high (only 0.1 in our study) when a waveform corresponding to the selected template is detected, a low correlation can be significant if it is substantially greater than the values obtained using the same template on surrounding stations. Therefore, in order to automatically detect the significant values of the correlation coefficient, a scaled array coefficient function (beam) is defined. It is similar to SNR and indicates the ratio between the beam at a certain time and the background level at surrounding times.

Evaluation Of The Methods And Comparison Of The Results With Other Networks

We compared our results with other networks in terms of detection capability. Tuba地震台 recorded 357 events in the period of 20-31 December 2007 (first twelve days) where The National Earthquake Monitoring Center network recorded 252 events within 0.5 – 5.5 recorded event as minimum 5.5 magnitude. By the end of that year, the detection of Keskin short period array detected 112 earthquakes within 0.5 – 5.5 magnitude range using STA/LTA method and 156 earthquakes within 0.5 – 5.5 magnitude range using the waveform correlation (Figure 7). These results indicate that, array databases have much higher detection rate than the single site and waveform correlation can detect lower magnitude events than standard STA/LTA methods (Figure 8).

References


Figure 1. Keskin short period array, geometric layout. This array has a circular shape with 15 m radius. The elements of the array consist of 12 2.4-kg broadband and six short period vertical sensors arranged in a hexagon form on a short period vertical seismic array frame.

Figure 2. A recording of Bala aftershock sequence in Keskin short period array during we have a good signal to noise ratio to show degree of the earthquake activity.

Figure 3. For this study a waveform correlation detector was prepared using the December 27 event as a signal template. The selected master waveform consists of 60 s of data beginning at the predicted P arrival for the given master event.

Figure 4. Shows the detection of an aftershock by waveform cross-correlation. This event has a magnitude of ML = 2.7, a correlation coefficient of 0.435, and a scaled array coefficient value of 11.3. There are only three channels present in this figure (BR1, BR102, BR103), and MS represents the master station event. Segments of the waveforms from the master event were extracted and cross-correlated with the filtered data (between 4.0 and 8.0 Hz.) from the target station waveform. Single-channel traces do not indicate clear discernible peak valuse, but a subsequent zero-delay stacking of all of the correlating channels results in an array correlation beam with a clear maximum peak at 2007-12-27T18:39:42.49. The scaled array correlation beam value of 11.33 indicates a high degree of waveform similarity. These thresholds were selected based on Figure 5.

Figure 4. Detection of an aftershock of a magnitude ML = 2.7 event by waveform cross-correlation: The origin time of the event is 2007-12-27T18:39:42.49. Each of the array’s detected vertical channels was band-pass filtered between 4.0 and 8.0 Hz. The horizontal data was extracted from the master station events shown as MS in the figure. Data containing the aftershock is filtered at the same band as correlation was calculated for each channel. Single-channel traces do not indicate clear discernible peak valuse, but a subsequent zero-delay stacking of all of the correlating channels results in an array correlation beam with a clear maximum peak at 2007-12-27T18:39:42.49. The scaled array correlation beam value of 11.33 indicates a high degree of waveform similarity. These thresholds were selected based on Figure 5.

Figure 5. 1. Preliminary detections by 01 December 2007 and 31 December 2007 for waveform correlation on the Keskin array where the template consists of 0.2 periods of dominant signal segments filtered between 4.0 and 8.0 Hz. After the network was delayed on December date 31, the array correlation coefficient values are higher than 0.1, indicating that these events lying in the same higher 0.1-1 range to be a seismic event. An earthquake at the detected location did not occur (1) were regarded as false detections and discarded.

At the end of the analysis we had detected 1,419 events within the magnitude range of 0.5-6.0 using array-based waveform correlation method.