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APPLICATIONS OF ADVANCED ARRAY TECHNIQUES IN GEOMETRICALLY LIMITED SEISMIC ARRAYS: CASE OF PIRES

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A cooperative project between Bogazici University Kandilli Observatory and Earthquake Research Institute (Istanbul, Turkey) and GFZ German Research Centre for Geosciences, Helmholtz Centre (Potsdam, Germany) is initiated in order to study the western part of the North Anatolian Fault Zone (NAFZ), crossing the Cinarcik Basin in Marmara Sea.

For this purpose, two seismic arrays (PIRES) are installed on two islands (Sivriada and Yassiada) to permit high resolution monitoring of seismic gap south of Istanbul that produces few and very low magnitude microseismicity. PIRES Arrays, Sivriada and Yassiada have 5 stations on each of them, one of the stations being in the center, with station spacing of ~100 m and aperture ~300 m. In addition to the arrays, PIRES seismic network is extended by installing at least one station to each of the neighboring islands (Balikciada, Burgazada, Heybeliada, Kinaliada and Buyukada).

Using the priori waveform templates of earthquakes that have occurred within ~20 km distance to the PIRES arrays, the presence of earthquake clusters nearby have been investigated with array based cross correlation methods. In order to find the presence of very small events, we have stacked the cross correlation traces on two arrays that resulted with a significant gain in Signal to Noise Ratio (SNR).

Following the cluster detection process, locations of the main events of the clusters were done using the P and S phase readings from the PIRES arrays, PIRES single stations and available land stations of National Earthquake Monitoring Center. In addition to the phase information, we have incorporated the backazimuth values, obtained from the subsequent F-K analysis. These procedures have largely contributed to the improvement of the depth root mean square (RMS) results and earlier locations which were done using the conventional methods.

I was supported to carry out part of the analysis at NORSAR by funding provided under the Seventh Framework Programme (FP7), Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation (NERA) Project. I had the opportunity to share their experiences on array seismology in particular using the F-K analysis program, Fyen (1989), for my own purposes.

In addition to inherent problems related to the use of F-K analysis, the configuration of PIRES Arrays itself resulted extra complications. These include; number of stations, differences in amplitudes between the stations due to elevation and topography underneath the stations, incoherent waveforms in a very small station spacing and possible local crustal velocity differences (Schweitzer et al., 2012) (Figure 1). Accordingly, an effort was made to fine tune and make full use of the method in the

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presence of station number limitations and other shortcomings. For instance, we normalize the amplitudes before beam forming in order to obtain a good amplitude coherency between the array stations.

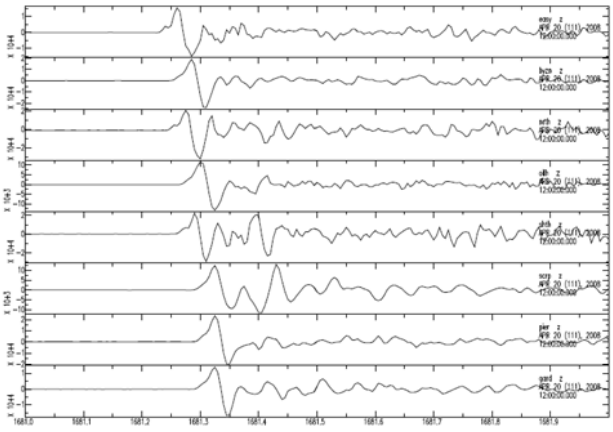

Figure 1. Zoom of the P phases of array stations

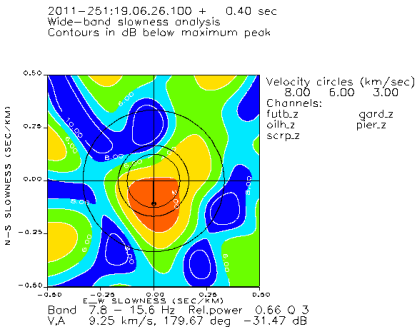

Figure 2. F-K analysis result

The distance between Sivriada and Yassiada is approximately 2 km which gave us the opportunity to compare the performances of F-K analysis for several different configurations; for only Sivriada, only Yassiada and both islands unified and treated as one big array cases.

In order to increase the accuracy, slowness values computed over a grid of 401X401 points. For every one of these grid points, the beam power is evaluated, giving an equally spaced grid of 160801 points which means a very high resolution.

F-K analysis technique that has been used, is the broadband F-K analysis proposed by Kværna and Doornbos (1986), because of increased stability and high SNR over the selected broadband frequency range (Kværna and Doornbos 1986) and (Kværna and Ringdal 1986) (Figure 2).

In practice, F-K analysis is performed in the frequency domain and beam forming is also done in the frequency domain for a number of different slowness values. But, it can also be performed in the time domain which takes longer calculation time. Results of these two approaches will also be shown.

Although PIRES Arrays are spatially limited to the size of islands, it still has the ability to make useful application of beam forming. A detailed discussion of encountered problems will be presented.

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