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Automated Determination of Polarity and Amplitude Ratios for Estimation of Fault Plane Solutions

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SUMMARY

More than 5000 were localized with 924 recorded at more than 7 stations. Their polarities and amplitudes as well as beach balls were determined and plotted. 188 were recorded at more than 7 station and had a misfit of less than 10 are used for further studies and interpretations.
The automatization was a successfully applied to a data set of local seismicity in Northern Chile. Now it is less time consuming to pick polarities and amplitudes. The four criteria which were used to determine the parameters have to be defined more precisely in the future in order to increase the accurateness of the produced mechanisms. Another advantage lies in the application to not just seismology data sets but also microseismic data sets.

Introduction

This work was done in order to simplify and automatize the process of analyzing and determining the polarity and amplitude of more than 5000 localized events. The created algorithm can be used for different data sets and was applied to a data set of local seismicity in Northern Chile. Prior to this work Bloch (2012) already analyzed a smaller set of events within this data set which consists of events extracted from continuous data that were recorded from 2005 - 2012 by two local seismometer arrays in Northern Chile (see figure 1). The Atacama-Fault-Network (AF) is situated near the coast above the Atacama Fault Zone and consists of 12 stations. The West-Fissure-Network (WF) is at the Precordilleras in the east, above the West Fissure Fault Zone, and consists of 17 stations (see figure 1). Both station arrays were recording with 200 Hz sample rate. Based on the extended analysis of 1265 events an algorithm was created to decrease the time spent on picking the polarity, P- & S-amplitude and amplitude ratio for the rest of the data set. Polarities and amplitudes were picked manually in a smaller set of events and were then used to test the consistency of the results from the algorithm.

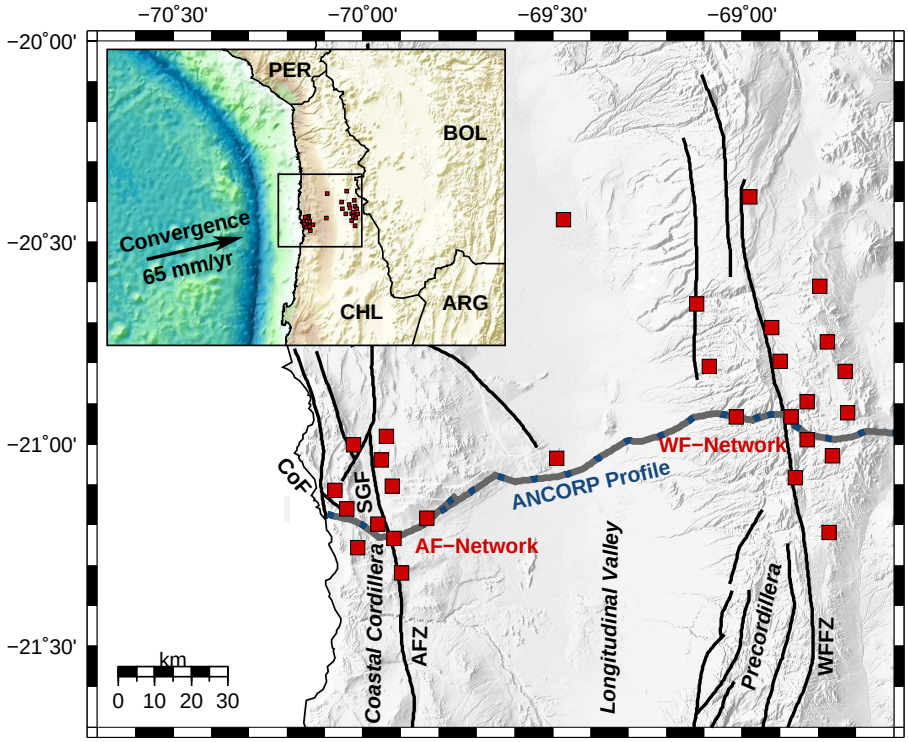

Figure 1 *Overview of the study area; red squares - seismic stations; black lines - faults in the shaded area; grey line with blue dots - profile of ANCORP Working Group (2003); adapted from Bloch et al. (2014).*

Processing

At first the continous data was loaded and local seismicity was detected. Each event file was then loaded into Matlab and analyzed separately. To find the polarity a small window of 200 samples (0.1s) was set. Within this window a fast fourier transformation was applied in order to obtain the dominant frequency f_{dom}. Using this frequency the analysis window (T_p to $T_p + 1/f_{dom} * c$) was defined. Multiplying the frequency with the constant (c) ensures that the window ends before half of the wavelength of the first arrival.
The derivative of the velocity and displacement traces were considered and within the analysis window the cross point was calculated. The time of this cross point was then used to find the sign of the velocity and displacement trace which were used as criteria to define the polarity and quality of the polarity. Two more criteria were defined by the sum of the amplitude within the analysis window in both traces.

According to the outcome of those four criteria a polarity and the quality were assigned for each event. In the end the maximum amplitude of P- and S-Phase were detected. Those parameters and the S-P-Amplitude ratio were exported to HASH [Hardebeck and Shearer (2002)] in order to calculate the mechanisms (see figure 2).

Results

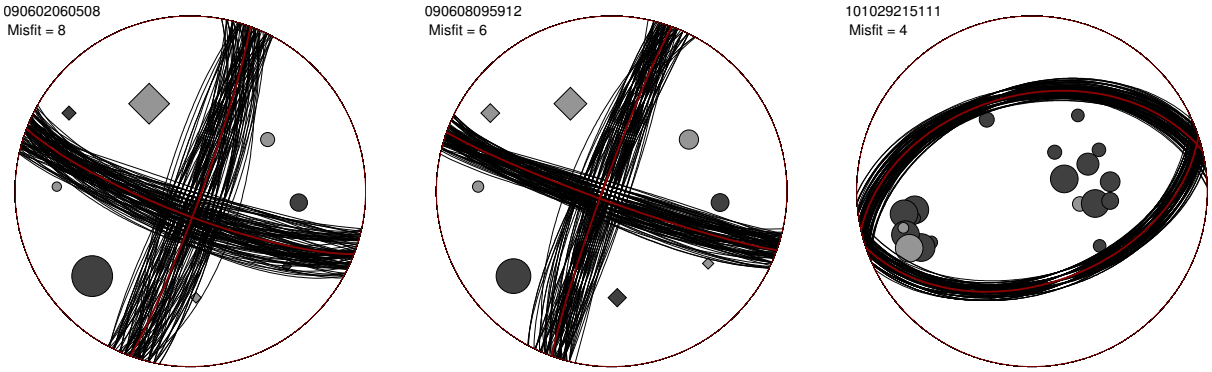

Figure 2 *Beach balls resulting from the algorithm; diamond shape - negative polarity; circle - positive polarity; dark - good quality; bright - moderate quality.*

From ∼5000 located events, 924 were analysed using this algorithm and 188 were extracted with well constraint focal mechanisms. The three displayed ones are just a selection from the 188 beach balls with more than 7 stations recording the event and a misfit of less than 10.

Conclusions

The automatization of the picking process was successfully applied to a data set of local seismicity in Northern Chile .Now it is less time consuming to determine the P-Phase polarity and P- & S-Amplitudes. Furthermore the quality gives a hint at the confidence level of the parameters. In order to increase the accurateness it is neccessary to introduce more criteria and make sure that the picking of the polarity is not just depending on the frequency determined by the fast fourier transformation.
In the future the beach balls have to be interpreted and analyzed according to their occurence location to get an image of the subsurface structures. This algorithm cannot only be applied to a seismology data set using a big scale but also to a microseismic data set at reservoir scale.

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