Detection of P-S travel time for Low SNR Event using polarization

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Detection of low signal-to-noise ratio (SNR) microseismic events provides a way to understand subsurface reservoirs. We propose a feasible method for detecting S-wave arrivals of low SNR events. We introduce 3D particle motion analysis to characterize the polarization of the waveform. We capture the direct S-wave particle motion depicting a flat shape (planarity) and P-wave arrival polarization perpendicular to the S-wave arrival polarization (perpendicularity). Previous studies have introduced spectral matrix (SPM) analysis to characterize 3D particle motion in the time and frequency domains and detected P-wave arrivals for low SNR microseismic events. SPM analysis can detect coherent seismic arrivals but is insufficient to measure S-wave arrivals.
To distinguish S-wave from noise and detect S-wave arrivals, we introduce the time delay coordinates of the SPM. We refer to the new SPM matrix as the extended spectral matrix (Ext-SPM). We evaluate the planarity and perpendicularity of the polarization in the time and frequency domains by introducing the Ext-SPM analysis method and combining them into one characteristic function. Then, we set a threshold of characteristic function to detect S-wave arrival times. The P-S travel time is the difference between the P-wave and S-wave arrival times. The P-S travel time results allow us to localize the hypocenter of the event. We apply our method to field data recorded at the Groningen field in the Netherlands to detect catalog events as well as low SNR events.
Zhang et al., 2019 proposed a rapid seismic association and localization (REAL) method, which mainly associates the arrivals of different seismic phases and locates seismic events by calculating the number of P and S picks and travel time residuals. We also attempt to locate those detected low SNR events using the P-S travel time.

Keywords: Low SNR events, Polarization, S-wave arrival detection, Time and frequency analysis, P-S travel time detection

