Case Study of the Effect of Grid-Search Objective Function in Microseismic Source Location

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Abstract

Source location of the microseismic events is a crucial issue in microseismic monitoring as it can provide a wealth of information that can help the delineation of the hydraulic fractures. Generally, a microseismic event occurs at an unknown time and unknown location. By using the arrival times of the P- and S-waves of the microseismic event, an estimate of the source location and origin time can be made through utilizing a grid-search algorithm. The accuracy of the source locations is affected by a variety of factors, such as the layout of the receiver arrays, the accuracy of the arrival picks and the velocity model. However, the choice of the objective function in grid-search algorithm is essential for locating the microseismic events because the grid-search algorithm treats the global minimum of the objective function as the estimated source location. In this study, we have discussed how the objective function affects the accuracy of the location results.

The objective function is usually chosen as the square sum of the time residuals between the observed and calculated P- or S-wave traveltimes. Through synthetic data tests, we have shown that this objective function is non-convergent in horizontal direction. However, it has also shown that the joint use of downhole and surface receiver arrays can reduce the non-convergence. Nevertheless, there are very few cases in practice where an optimal recording system can be employed, so we have proposed a new objective function to help address this problem. Studies have shown that the P- and S-wave moveouts determine the source depth while the P-S time differences determine the distance. The new objective function is made up of these three parts. The effectiveness of the new objective function is examined on synthetic data sets. It has been shown that the new objective function is more convergent than the traditional ones, which implies that it can produce more accurate location results. In addition, we have tested the performance of the new objective function in the presence of picking errors, and we can observe that the location errors of the new objective function are the smallest when comparing with the traditional ones. Finally, the influence of the velocity model and source location has also been examined, and the results show that these two factors have limited impacts on the convergence of the new objective function.