A non-scale factor dependent Marchenko internal multiple attenuation approach

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Abstract

The internal multiple reflections normally represent the main coherent noise in measured seismic data, and many techniques have been proposed for their attenuation. The advent of the Marchenko multiples elimination scheme (MME) generated enthusiasm among scholars of seismic exploration, due to its capacity to attenuate internal multiples of all orders with a high degree of precision without velocity information. However, it can be observed experimentally that for the MME to work effectively it is required that the amplitudes of the seismic data be normalized by an optimal global scale factor (SF). Normally, if the SF used is greater than the optimum, the MME tends to create numerical noise with high amplitudes in the data, while on the other hand, if the SF used is less than the optimum, the MME tends to be inefficient in attenuating the multiples. As there is no scheme capable of obtaining the optimal SF, the efficiency of the MME depends on the ability to empirically obtain it. An alternative solution based on the Beyond Neumann method (BNMME) was proposed to reduce this scale factor dependence, but despite being less dependent on the SF, the BNMME solution requires a good approximation of it to obtain satisfactory results.

To try to eliminate the MME scale factor dependence, we proposed to combine the MME with an adaptive filter to present the adaptive filter-based MME approach (AMME). This scheme is applied in two steps: first, the MME is used to predict the opposite internal multiples, and afterward, an adaptative filter was used to tune the events amplitudes and sum them with the measured data, generating the multiples-free data. To develop the AMME scheme, we initially rewrote the MME to be applied shot by shot and to estimate opposite events for these shots, and then we wrote an adaptive filter scheme inversion-based to tune the amplitude of the events.

The further away the used SF is from the optimal, less effective will be MME in attenuating the internal multiples, however, in the AMME the scale factor is not relevant. To prove this, we tested the AMME in comparison with MME in two situations using a numerical example. So, we model a seismic dataset using the synthetic model that has an optimal scale factor known as SF=2.0 and use the MME and AMME schemes to attenuate their internal multiples, in two situations, first using SF=2.0 and next with SF=1.0. The results show that if SF=2.0, the MME is the best alternative, however, if SF=1.0 the MME is fully inefficient because the predicted events have low amplitude in comparison with the measured data. However, the AMME scheme was able to significantly attenuate the multiples regardless of the value of SF.

We tested AMME on an example where optimal SF is known, but in-field datasets, it is impractical to obtain this, requiring many tests to obtain a good approximation of this. Because it is SF-independent, the AMME avoids this exigence and can be easily applied to mitigate this noise.