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Target-oriented elastic full-waveform inversion through acoustic extended migration redatuming

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Summary

Elastic full-waveform inversion (FWI) has the potential of simultaneously invert all the scales of the elastic subsurface model while accounting for the elastic effects present in the recorded data. However, its application on production field datasets is limited by its high computational cost. In fact, the computational time of the elastic Green's functions involved during any data inversion is much higher compared to the cost of the acoustic ones.

Abstract

Elastic full-waveform inversion (FWI) has the potential of simultaneously invert all the scales of the elastic subsurface model while accounting for the elastic effects present in the recorded data. However, its application on production field datasets is limited by its high computational cost. In fact, the computational time of the elastic Green's functions involved during any data inversion is much higher compared to the cost of the acoustic ones.

Despite this issue, in most of the real applications, high resolution elastic property models are required within limited portions of the entire subsurface (e.g., within the reservoirs). With this concept in mind, we propose a target-orient elastic FWI approach where localized elastic data are reconstructed within the area of interest using extended acoustic least-squares migration and then elastically inverted. The data reconstruction enables us to limit the elastic Green's functions computation only within the area of interest. In order to perform the acoustic least-squares migration we assume that a relatively correct and smooth compressional velocity model is known. The goal of the acoustic extended migration is to map the elastic data difference between the observed pressure and the one generated by the initial entire elastic model into a localized area of interest of the subsurface. In this operation we assume that most of the energy in the data difference is generated within the target inversion area. The extension of the scattering condition enables us to fully capture all the events present in the data difference. In fact, elastic effects and multiple scattering occurring in the target area can be modeled by the inverted extended perturbation. After performing this migration procedure, we model the background elastic data only within the area of interest and add to them the demigrated data constructed using the inverted extended perturbation. This reconstructed data is comparable to the one that would have been recorded if the propagations were occurring only within the true target portion of the subsurface. Therefore, the reconstructed data can be used to perform an elastic FWI to obtain the high-resolution model within the area of interest.

We test our proposed approach on two synthetic 2D examples; a layered model in which a deep sinusoidal reflector is considered to be the inversion target and a localized area of the Marmousi2 model. First, we compare the reconstructed pressure with the true data recorded only within the area of interest. Then, we also compare the elastic inverted models using these two datasets to assess the agreement of the two inversions.