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Application of efficient frequency-domain full waveform inversion using time-domain encoded simultaneous sources

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Abstract

Full waveform inversion (FWI) is used to determine accurate subsurface velocities through recursive calculation. FWI needs extensive computation; therefore, reducing the computational cost while inverting for an acceptable result is important for the practical application of FWI. Frequency-domain FWI has the advantages of selection of certain frequency components and reduced computational time because of the use of a matrix solver, which solves many sources simultaneously through one matrix factorization. However, the size of the matrix increases exponentially with the size of the computational domain and the number of parameters. The efficiency of frequency-domain FWI decreases in 3D FWI because of limited computational memory. To enhance the efficiency of frequency-domain FWI, time-domain modeling with a simultaneous source was exploited in this study. Although the time-domain modeling scheme is one of the most efficient methods for performing 3D frequency-domain FWI, it still requires time-marching for every source. However, the efficiency can be greatly improved by using the simultaneous source method. Moreover, this method is not limited by the amount of memory required because the time-domain modeling scheme is a matrix-free method. To suppress the crosstalk noise in the simultaneous source method, we use random phase (RP) encoding, random time delay (RTD), and the partial-source assembling method. The nonlinear conjugate gradient method (NLCG) is also used to accelerate the convergence speed. To validate the efficiency of the proposed algorithm, a numerical test is conducted using the 2D SEG/EAGE overthrust model and shows that determining the appropriate balance between the computational cost and the quality of the result can improve the efficiency of the encoded simultaneous source FWI (ESSFWI). The 3D numerical test also verified that the proposed algorithm enhances the computational efficiency and guarantees the quality of the inverted result.

Author keywords

Encoded simultaneous source Frequency domain Full waveform inversion Time domain

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