Traveltime-based Reflection Full Waveform Inversion With Low-wavenumber Enhancement Using Energy Norm Born Modeling

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Abstract

Objectives/Scope: Traveltime-based Reflection Full Waveform Inversion (RFWI) measures the kinematic differences between recorded and predicted data, and can better tackle cycle skipping than conventional RFWI which depends on waveform residuals. In RFWI, transmission wavefields generated by conventional Born modeling produce high-wavenumber artifacts in the computed gradient. We show that using the Born modeling based on the adjoint of energy norm imaging can attenuate the artifacts and enhance the low-wavenumber components of the computed gradient.

Methods, Procedures, Process: In RFWI, the low-wavenumber tomographic component of the gradient is explicitly computed by summing the cross-correlation of the source-side wavefields and the receiver-side scattered wavefields, and the cross-correlation of the source-side scattered wavefields and receiver-side wavefields. The traveltime-based RFWI utilizes a misfit function that measures the kinematic differences to reduce the nonlinearity in inversion. The scattered wavefields generated by conventional Born modeling include both transmissions and reflections. The transmissions produce high-wavenumber artifacts in the gradient. The Born modeling based on the adjoint of energy norm imaging condition is utilized to attenuate transmissions and improve the smoothness of the computed gradient.

Results, Observations, Conclusions: Our numerical tests show that the Born modeling based on the adjoint of energy norm imaging condition can attenuate transmission wavefields and produce clean reflections. By using this energy norm Born modeling to generate source-side and receiver-side scattered wavefields, we can suppress the high-wavenumber migration artifacts in the computed gradient for traveltime-based RFWI. The low-wavenumber enhanced gradient produced using the energy norm Born modeling can further improve the convergence during the inversion process for velocity updating.

Novel/Additive Information: The adoption of the linearized modeling based on the adjoint of the energy norm imaging condition in the traveltime-based RFWI can efficiently and effectively attenuate high-wavenumber artifacts in the computed gradient. The promotion of the low-wavenumber component and the improved smoothness in the constructed gradient play a crucial role in reliable background velocity update using reflections.