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Dynamic Resolution TLFWI to Maximize the Contribution of Reflections for Velocity Model Building

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Objective (25-75)
Full-waveform inversion (FWI) uses the full wavefield as input but, in general, diving waves are the key driver of the method. Maximizing the contribution of reflected waves is an important factor for successful application of FWI, especially on seismic data with a short-offset coverage. We propose Dynamic Resolution Time-Lag FWI (DR-TLFWI) to better utilize the reflections, especially for low-wavenumber velocity updates for better kinematics.

Methods (75-100)
The FWI gradient consists of three terms: contribution from diving waves, migration term and tomographic term from reflected waves. The tomographic term generated by reflections is often much weaker than the other two. The proposed method compensates for the weak tomographic term in the FWI gradient by a dynamic weighting derived from the corresponding illumination volume in each iteration. We use the time-lag cost function to avoid the dominance of strong amplitudes and to mitigate cycle-skipping issues.

Results (100-200)
Although advanced acquisition technology has brought great convenience to seismic imaging, there is still a large amount of suboptimal seismic data to be processed, and reflection energy accounts for the majority of those types of seismic data but appears under-utilized in FWI. DR-TLFWI is proposed to maximize the contributions from reflections. It captures the fast lateral variation on velocity models and corrects the image undulations for better structural interpretation. Figure 1 shows a comparison between DR-TLFWI and TLFWI on synthetic data, both inverting from the same input velocity which is far from true. With enhanced tomographic term, DR-TLFWI further corrects the velocity error beyond the diving wave penetration and leads to flatter image gathers and better structural positioning. Figure 2 depicts the application of DR-TLFWI on conventional streamer data from NWS, Australia. DR-TLFWI captures the complex velocity variations in the overburden, thereby greatly reducing the structural undulations in the final image displayed in Figures 2 (e) and (f). The velocity, shown in Figure 2 (d), reveals fine details of the structures which may help with geologic interpretation.

Novel (25-75)

One key factor to better utilize the reflections for low wavenumber velocity update is how to enhance the weak tomographic term. We propose a new compensation approach inspired by the root cause of the weak tomographic term, i.e. the tomographic term is formed by reflected wavefields which have experienced additional scattering compared to forming the migration term. A dynamic weighting is predicted in each iteration and applied to enhance tomographic term accordingly.

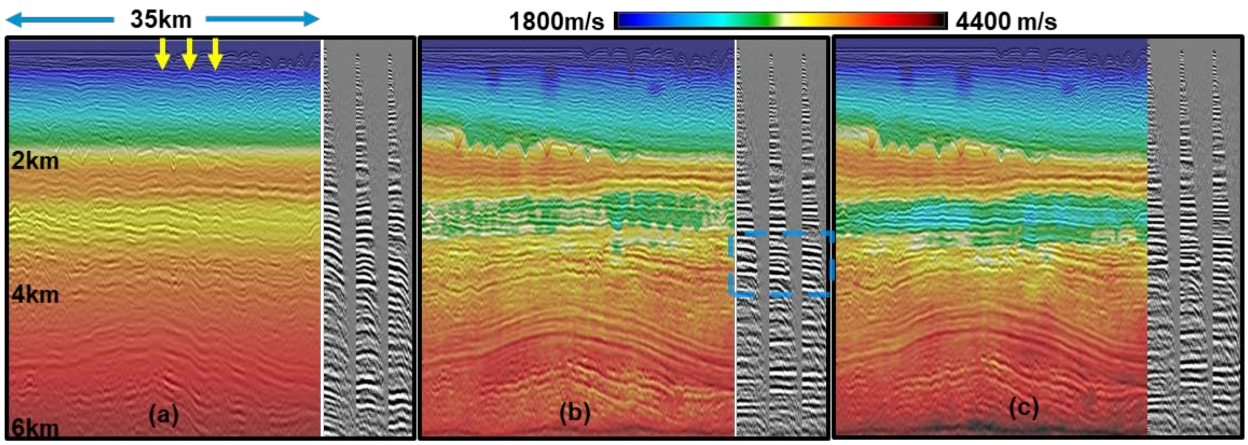

Figure 1 Velocity overlaid on PSDM stack and selected CIGs with the location indicated by yellow arrows from (a) initial velocity, (b) TLFWI inverted velocity and (c) DR-TLFWI inverted velocity.

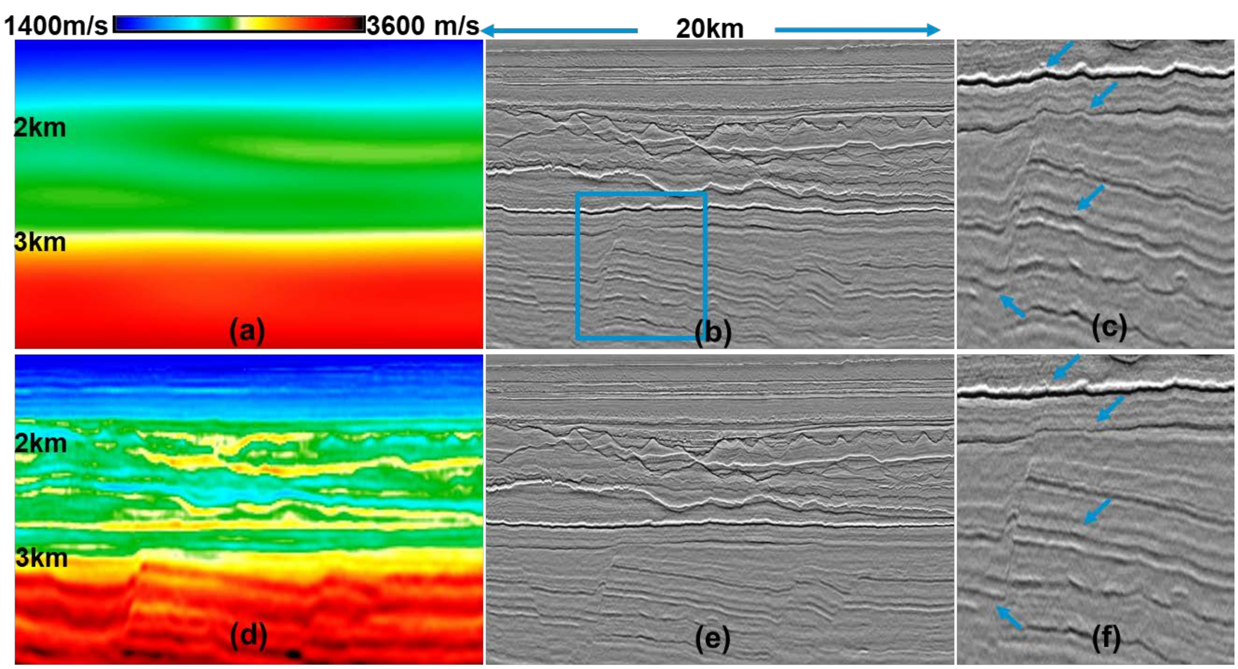

Figure 2 Velocity, PSDM stack and zoomed-in section at rectangle zone, from (a~c) initial velocity, (d~f) DR-TLFWI inverted velocity.