Enhanced One-way Wave Equation Migration

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Abstract

Objectives/Scope: Velocity errors are inevitable for the model building of field datasets in current production. Therefore, it is of high significance to improve seismic imaging in the presence of velocity errors. We propose an enhanced one-way wave equation (OWE) migration technique that can greatly improve the imaging quality when velocity model is inaccurate but achieve almost same result with the conventional OWE migration given an accurate velocity model.

Methods, Procedures, Process: Our method first decomposes extrapolated receiver wavefields at every imaging point into local plane waves by a computationally efficient recursive Radon transform. Following that, the decomposed wavefields are zero lag-correlated with the incident source wavefields over all the shots, resulting in multiple migrated images corresponding to different local plane-wave slopes. Finally, we merge all the local-plane-wave images into a whole image by using an adaptive merging algorithm to select the comparatively high-quality subsections from each image, and further obtain an improved image with high signal-to-noise ratio and better coherency.

Results, Observations, Conclusions: We evaluate our method using a synthetic dataset from the SEAM II Arid model and a marine dataset. The results from the synthetic data tests show that our method can produce high-quality images comparable to those produced by phase shift plus interpolation (PSPI) migration when an accurate velocity model is available. However, given an inaccurate velocity model, our method produces significantly improved images compared to conventional results. Regarding the efficiency, the recursive Radon transform algorithm reduces the computational complexity from O(M×N²) of conventional transform to O(M×N) by avoiding the recalculation of shared points between adjacent windows, where M and N are the number of plane slopes and horizontal samples, respectively. In this example, the PSPI method took 16.3 minutes to complete the migration while the enhance PSPI method required 35.3 minutes using the same parameters and computational resources. The marine data tests further confirm that the enhanced OWE method produces images with improved event coherence, better focusing, and fewer artifacts, compared to conventional OWE migration.

Novel/Additive Information: We present an enhance OWE migration method to improve seismic images in the presence of velocity errors. Our method extends the extrapolated wavefields using the local plane-wave slopes. Such data-domain extension provides room to handle velocity errors, because each slope component corresponds to different levels of distortions by the velocity error. By adaptively selecting the image components that are minimally affected by velocity errors, we can ameliorate the image quality in the present of errors. This method is very user-friendly as the depth range for image improvement is convenient to adjust.