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2.5D true-amplitude offset continuation

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ABSTRACT

Configuration transform operations such as offset continuation have a variety of uses in seismic processing. Offset continuation, i.e., the transformation of one common-offset section into another can be realized as a Kirchhoff-type stacking operation for 3D wave propagation in a 2D laterally inhomogeneous medium. By application of a suitable weight function amplitudes of the data are transformed by replacing the geometrical-spreading factor of the input reflections by the correct one of the output reflections. The necessary weight function can be computed via 2D dynamic ray tracing in a given macro-velocity model without any knowledge about a possible reflector. Numerical examples show that such a transformation can be realized with high accuracy.

INTRODUCTION

Configuration transforms like dip-moveout correction (DMO), migration to zero-offset (MZO), shot or offset continuation (SCO and OCO), and azimuth-moveout correction (AMO) have become a field of great interest in exploration seismics. The objective of a configuration transform is to simulate a seismic section as if obtained with a certain measurement configuration using the data measured with another configuration. This type of imaging process is not only useful in the seismic processing chain for an improved stack, i.e., for data reduction and signal-to-noise enhancement, but also for wave-equation-based trace interpolation to reconstruct missing data and for velocity analysis. Recent publications in the area, that demonstrate the use of configuration transforms for these purposes, include the following ones on MZO (Bleistein and Cohen, 1995), OCO (Fomel and Bleistein, 1996), SCO (Bagaini and Spagnolini, 1996), AMO (Biondi et al., 1996), and DMO (Canning and Gardner, 1996; Collins, 1997).

The objective of the true-amplitude offset continuation (OCO) to be presented in this paper is to transform one common offset section into another common-offset section with a different offset, such that the geometrical-spreading factors are automatically accounted for. It is based on the general 3D Kirchhoff-type formula for configuration transforms of Tygel et al. (1996). In that paper, a unified approach to amplitude-preserving seismic

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reflection imaging is provided for the case of a 3D seismic record with an arbitrary measurement configuration and assuming a laterally and vertically inhomogeneous, isotropic macro-velocity model.

We consider here a 2.5D situation, i.e., 3D wave propagation in a 2D (isotropic, vertically and laterally inhomogeneous) earth model. There exist no medium variations in the out-of-plane y-direction perpendicular to the seismic line. In particular, all reflectors can be specified by in-plane (x, z)-curves. Moreover, all point sources, assumed to omnidirectionally emit identical pulses, and all receivers, assumed to have identical characteristics, are distributed along the x-axis so that only in-plane propagation needs to be considered. For the 2.5D problem, the full 3D geometrical-spreading factor of an in-plane ray can be written as product of in-plane and out-of-plane factors (Bleistein, 1986). Both quantities can be computed using 2D dynamic ray tracing (Cervený, 1987).

The common-offset measurement configurations are parameterized by their midpoint and half-offset coordinates ξ_j and h_j. The index $j = 1$ is related to the input common-offset configuration and $j = 2$ to the output configuration. On the measurement surface $z = 0$ and along the seismic line $y = 0$, these coordinates define the locations of pairs of sources $S_j = S(\xi_j) = (\xi_j - h_j, 0, 0)$ and receivers $G_j = G(\xi_j) = (\xi_j + h_j, 0, 0)$. At each receiver position G_j, a scalar wavefield induced by the corresponding point source at S_j is recorded. In the following, we assume that each (real) seismic trace in the input section has already been transformed into its corresponding analytic (complex) trace by adding the Hilbert transform of the original trace as imaginary part. Therefore, the output common-offset section will be also considered analytic. The analytic traces will be denoted by $U(\xi_j, t_j)$, where t_j is the time coordinate of the respective input or output sections. Both these sections are then described by $U(\xi_j, t_j)$ for a fixed h_j as well as varying ξ_j (confined to some aperture A_j) and t_j (confined to some interval $0 < t_j < T_j$).

CONCLUSION

In this paper we have formulated a new Kirchhoff-type approach to a true-amplitude offset continuation (OCO) for 2.5D in-plane reflections in 2D laterally inhomogeneous media with curved interfaces. Constructing true OCO amplitudes (in our sense) implies that in the transformed common-offset reflections the geometrical-spreading factor of the original common-offset reflection is replaced by the new one for the same reflection points. This goal is achieved by a weighted one-fold single-stack integral in the time domain along specific stacking lines. We stress that the operation does not rely on any prior knowledge about the arbitrarily curved reflectors to be imaged and is theoretically valid for any reflector dip. Thus, the true amplitude weight function can be computed by 2D dynamic ray tracing performed along ray segments that link the two common-offset pairs of source and receivers to certain points in the macro-velocity model.

First numerical results show that a true-amplitude OCO can be realized with high accuracy. In this way, an amplitude-variations-with-offset (AVO) analysis becomes possible in any arbitrary offset domain.

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PUBLICATIONS

Detailed results were presented at the Karlsruhe Workshop on Amplitude-Preserving Seismic Reflection Imaging and published in the Special Issue of Journal of Seismic Exploration (Santos et al., 1997).