SRME: Optimal modelling aperture

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This paper was prepared for presentation during the 14th International Congress of the Brazilian Geophysical Society held in Rio de Janeiro, Brazil, August 3-6, 2015.

Abstract

SRME has shown to be the most effective technique for multiple attenuation in nowadays industry. Its accuracy its strongly guided by the modelling aperture which affects both the computational costs and its quality. This work propose a methodology for specifying optimal variant aperture by the analysis of the energy reflected at the surface.

Introduction

In exploration seismology, multiples are generated by propagating energy that reflects more than once. Despite of its recent use as additional information in new imaging techniques, the multiple energy is classified as coherent noise by most of standard processing workflows e.g. velocity model building, and interpretation (Weglein, 1999). Surface-related multiples, are the multiples that reflected on the on the surface at least once.

Surface-Related Multiple Elimination, SRME, is a data-driven method that attenuates multiple reflections (Verschuur, 1992). The algorithm predicts all surface-related multiples, e.g., water-bottom multiples, peg-legs, diffracted multiples. The method consists of two essential steps: a) the modelling step, in which a dataset containing only multiple reflections is generated and (b) the multiple attenuation step that consists of an adaptive subtraction of the modelled multiples from the seismic data.

The multiple model generation is based on a proper combination of primary energy (Dragoset, 2010). As illustrated in Figure 2, the multiple energy path can be described as the combination of a primary path from the source location (red star) to Downward Reflection Point (DRP), with another path from the DRP (blue star) to the receiver location (yellow triangle).

An ideal multiple model requires two traces to generate the multiple trace, one that registered the wave-field from the source location to the DRP, and another one from the DRP to the receiver location. However, since the DRP location is not known a priori, all traces inside an aperture are considered, generating a Multiple Contribution Gather (MCG) with one trace for each DRP candidate.

As illustrated in Figure 2, the more complex the geology, the more scattered the DRP locations (McHugo, 2010). Thus, the multiple model reliability strongly depends on an appropriate choice of the modelling aperture, which will guarantee the right incorporation of the DRP's. Since the Fermat's principle of stationary time assures that the DRP location will be located at the apex of the travel-time curve, stacking MCG results in a constructive summation around appropriate DRP's, and attenuation of the false-positive DRP's.

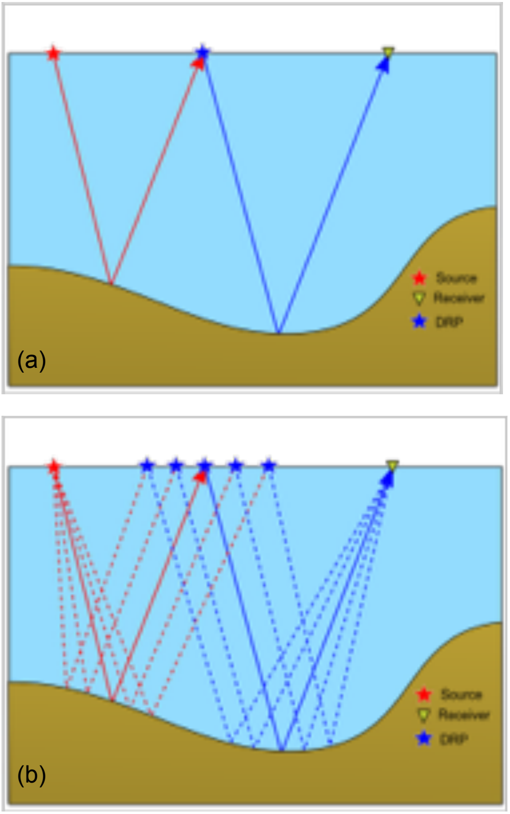

Figure 1. (a) Multiple energy path as a combination of two primary paths (red and blue). (b) Since the DRP location is not known a priori, in order to obtain the multiple path, all possible ray paths must be considered. Therefore, convolution of all energy emerging from the source (common-source gather) with all energy reaching the receiver (common-receiver gather) must be generated.

The model quality, on the other hand, relies on the relation between the number of appropriate and false-positive DRP's (Bienati, 2012). A big aperture, for example, guarantees the incorporation of the right DRP but decreases the model quality due to the higher amount of false-positives. Furthermore, since the modelling step

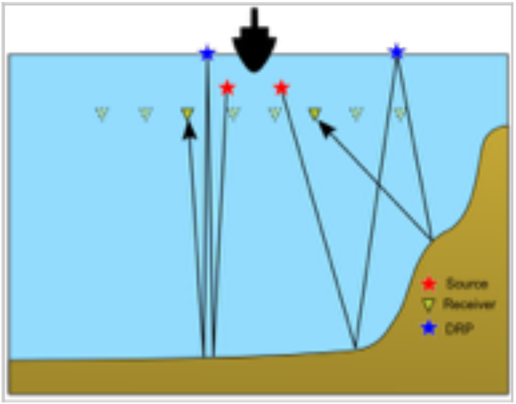

Figure 2. DRP scattering in complex and simple geology.

is computationally expensive, a proper aperture definition is critical for the efficiency of the complete processing sequence.

This work proposes an enhancement in the multiple modelling step by a methodology for defining a spatially variant optimised aperture.

Method

The technique consists of an analysis of the energy that reaches the surface and bounces back to subsurface. Given a multiple contribution gather **U(x,t)**, the multiple energy at time t can be approximated by

$$E(x,t)= \left|2\int_0^a \tilde{U}(k,t)e^{2\pi ikx}dk - \tilde{U}(0,t)\right| \quad (1)$$

where **Û(k,t)** is the one-dimensional Fourier transform of **U(x,t)**, and ***a*** is the stationarity parameter. Figure 3 illustrates this measurement.

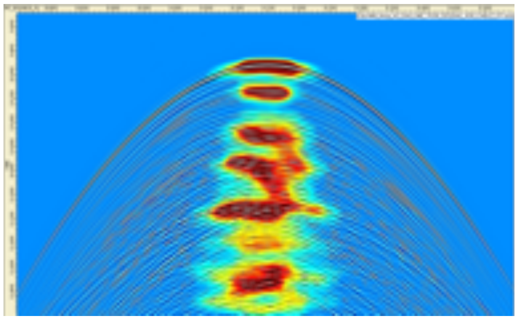

Figure 3. Multiple contribution gather and the multiple energy measurement over DRP candidates (overlay).

The optimal modelling aperture must include all DRPs with non-negligible energy. Therefore, we must consider all occurrences regardless of its time and DRP location on a accumulation curve (see Figure 4), namely

$$\overline{E(x)} = \int_0^T E(x,t)dt \qquad (2)$$

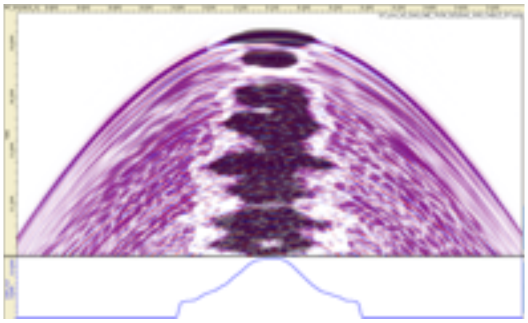

Figure 4. Example of the same MCG of Figure 2 with the multiple energy accumulation curve.

Results

The proposed analysis was performed on MCG´s along a 3D survey which water-bottom is depicted on Figure 5.

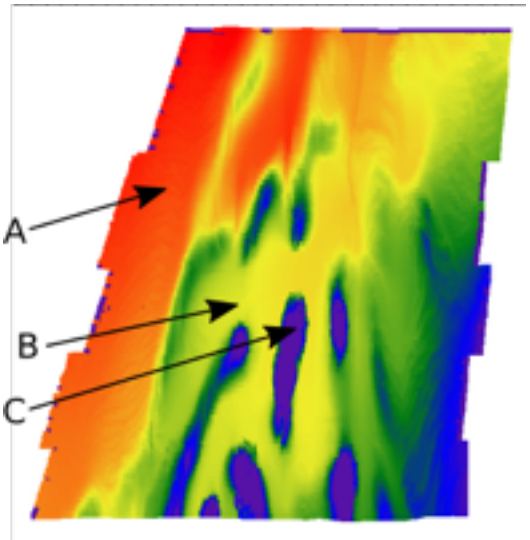

Figure 5. Water-bottom map with depth increasing from cold to warmer colours.

The MCG on Figures 3 and 4 was extracted from location A on Figure 5, which presents smooth water-bottom. As one may notice, the DRP´s are concentrated on the centre of horizontal axis.

Figure 6 presents the analysis performed on a MCG at location B. This area turns to be more complex than location A. The behaviour of the DRP's along the MCG represents the behaviour of how seismic energy scattered around this area.

Location C is represented by figure 7. As it was expected the energy scattering was higher than other areas due to its water bottom complexity.

Once the DRP's analysis behaviour is done along the survey, a suggested aperture map can be derived from it. Figure 8 depicts the suggested aperture map. The warmer colours represent areas which need aperture closer to the reference (with which MCG's were generated).

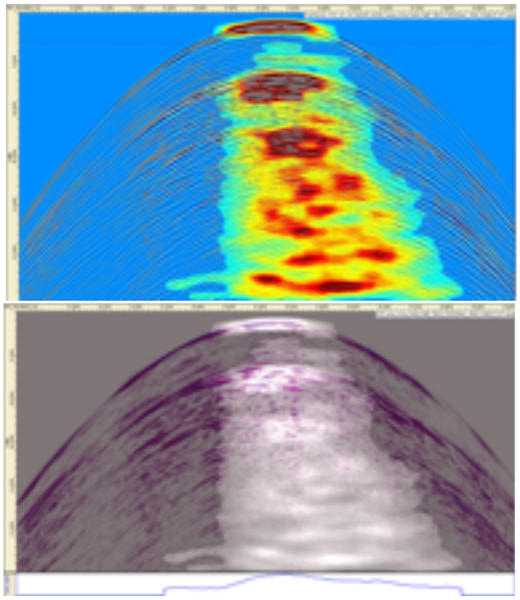

Figure 6. Multiple contribution gather and the multiple

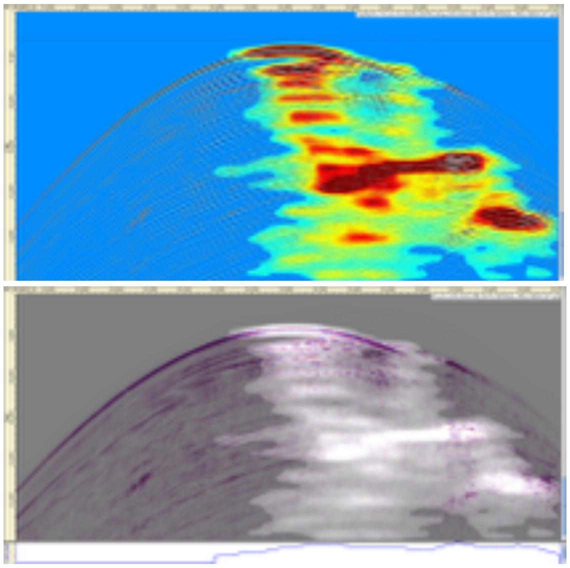

Figure 7. Multiple contribution gather and the multiple energy measurement over DRP candidates (overlay) for location B.

Conclusions

An enhancement in the multiple modelling step is achieved by defining a spatially variant optimised aperture. This analysis requires the generation of MCG's on a sparse grid location (in the presented case 1% out of the survey).

This analysis allows to decrease the modelling aperture from the reference along the survey. For the presented survey, the aperture could be reduced to 40% of the reference in less complex areas. On the other hand, for complex geology areas, the suggested aperture reaches 95% of the reference due to DRP scattering.

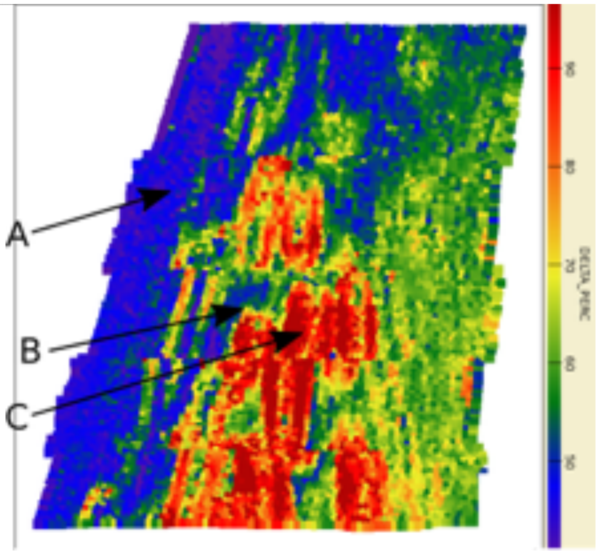

Figure 8. Suggested aperture map.

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