Multiple seismic reflections attenuation using parabolic Radon transform

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ABSTRACT:

In seismic reflection data analysis, noises are typically divided into coherent and incoherent. To increase data quality and recognize primary signals it is vital to attenuate these noises. Among which multiple reflections attenuation process is a serious challenge that a data analyst has to face.

Several Radon transform approaches have been widely thought and used by many researchers within the attenuating multiple reflections of seismic data. In this paper, parabolic radon remodels and their application in attenuating multiples reflections are performed. To validate the performance of the process, the method is applied to synthetic and experimental data consisting of two primaries and three multiples of first and second order. The results showed considerable attenuation of multiple reflection signals.

Keywords: Coherent noise, Multiple reflections attenuation, Parabolic Radon transform

INTRODUCTION:

Multiples:

The multiples are events that have run into more than one reflection. Since the amplitude of the multiples is proportional to the product of the reflection coefficients for each of the reflectors involved and the reflection coefficient is very small for most interfaces, only the contrasts with the highest impedance generate multiples that are equally strong enough to be recognized as special events. A long path multiple is one whose path is long compared to the primary reflections from the same deep interfaces, and therefore long path multiple appears as separate events in a seismic record.

A short path multiple, on the other hand, arrives so soon after the associated primary reflection from the same deep interface that it interferes and adds a tail to the primary reflection. Therefore, instead of creating a separate event, the waveform changes. The possible beam paths for these two classes are shown in figure

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Short-path multiple:

Multiple reflections in which energy is only reflected back and forth in a tiny part of the seismic section, so that the wave is mixed with the primary pulse and changes its waveform, and has a tail Added. See Figure 1, often referred to as the Peg-leg multiple**.**

Long-path multiple:

Seismic reflection, the path of which is significantly longer than necessary for a primary reflection from the deepest reached interface. The long-range multiple is typically shown as a separate event rather than merging at the end of the primary event. For example, energy may be reflected through a deeply reflective interface, then at or near the surface, and again through the same or a different deep interface(Sheriff, 2002). See Figure 1.

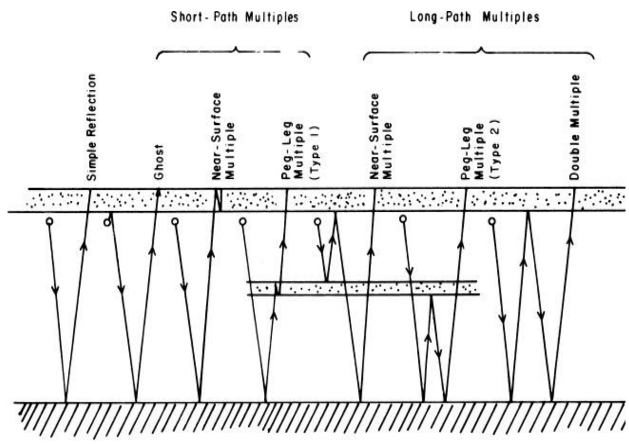

Figure 1. Multiple types

Multiple attenuation:

Multiple attenuation processes are seismic processing methods that are used to attenuate multiples. It is divided into three stages: first, the deconvolution process, which uses periodic repetition to remove multiple reflectors, second, the filtering method, which separates primary and multiple reflectors in specific domains, and finally, wave prediction and subtraction from seismic data (Kumar et al., 2008). Slant-stack or hyperbolic Radon transform and parabolic Radon transform are the two forms of Radon transform that are widely used to remove multiples (Cao, 2006). The radon transform is used to attenuate multiple waves depending on the variations in move-out between the main and multiple waves. Radon transform transforms domain data from the t-x domain to the $\tau - p$ domain, allowing the primary and multiple move-outs to be conveniently separated. Radon transformation is best suited for deep waters, but it is ineffective for complex subsurface (Yuza et al., 2020).

Parabolic Radon Transform:

Many reflections on an NMO-corrected CMP gather can be approximated as parabolic events (Hampson, 1986). By summing the data along the stacking paths defined by the equation:

$$t = \tau + qx^2$$

t is two-way travel time, x is offset and τ is intercept travel time and q known as horizontal Radon parameter:

$$q = {}^{1}\!/_{2t_0 v_r^2},$$

v_r is residual velocity, t_0 is zero-offset two-way travel time.
a parabolic Radon transform can be constructed on an NMO-corrected CMP gather. Theoretically, an exact parabolic curve in the CMP domain can be traced to a central point in the parabolic Radon transform. Yilmaz proposed a new description of the parabolic Radon transform, which is defined over a t^2-stretched shot gather since a hyperbola in the $t - x$ domain becomes an exact parabola after the time axis is t^2-stretched (Yilmaz, 1998). Consider the following events on a CMP gather with hyperbolic travel time:

$$t^2 = t_0^2 + \frac{x^2}{v^2}$$

then, in the time direction, expand by setting $t' = t^2$ and $t_0' = t_0^2$. Equation (3) then takes the following form:

$$t' = t_0' + \frac{x^2}{v^2}$$

which is a parabola concept. As a result, the parabolic Radon transform can be described over t^2-stretched CMP or shot gathers.

Methodology and data:

To remove multiples from the data, initially, they are NMO corrected. Then by using a parabolic Radon transform, the data are transformed to a parabolic domain, for which multiple reflections are separated from primaries. After attenuating multiples in the parabolic domain, the remaining data are transformed back into an offset-time domain using inverse parabolic Radon transform.
To validate the process, firstly, the method is applied to synthetic data that consists of two primaries and three multiples of first and second order.
Figure 2 (a) shows a synthetic shot gather data. At 0.5 seconds, the first primary and first and second-order multiples of the first primary are present at 1 and 1.5 seconds, respectively. The second primary reflections can be seen in 0.8 seconds and the first-order multiple of the second primary in 1.6 times, respectively. Figure 2 (b) shows the velocity panel used for NMO corrections; the velocity values used are shown with star symbols. The NMO corrected data is shown in Figure 2 (c), where the primaries are present flat and multiples are curved.
Figure 2 (d) shows the attenuated data from the above study method, in which multiple waves are removed from the data. To have better insight from the ability of the applied method, the data are restored to their original state, i.e., we return the NMO corrections that we performed earlier, the result is shown in Figure 2 (e). The attenuated multiple reflections are shown in Figure 2 (f).

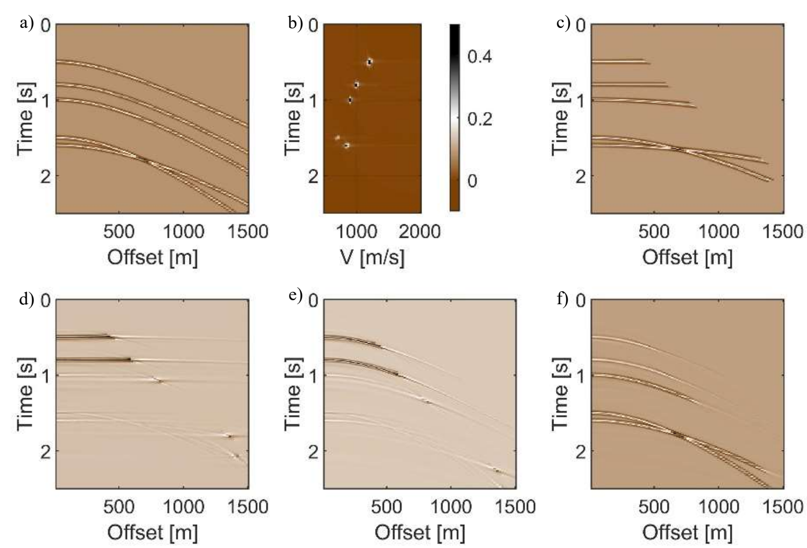

Figure 2: a) Synthetic marine data. b) Velocity panel. c) NMO corrected data. d) Filtered data. e) Inverse NMO of (d). f) Extracted multiples from (c)

Figure 4 (a) shows experimental marine data after NMO correction, the result of applying a parabolic Radon transform to the data is shown in Figure 4 (b) and the attenuated multiples reflection is shown in Figure 4 (c).

CONCLUSION:

Parabolic Radon transform is an effective method in attenuating multiple reflections based on velocity analysis. Applying this method makes it possible to attenuate a large range of multiple reflections with different trajectories.

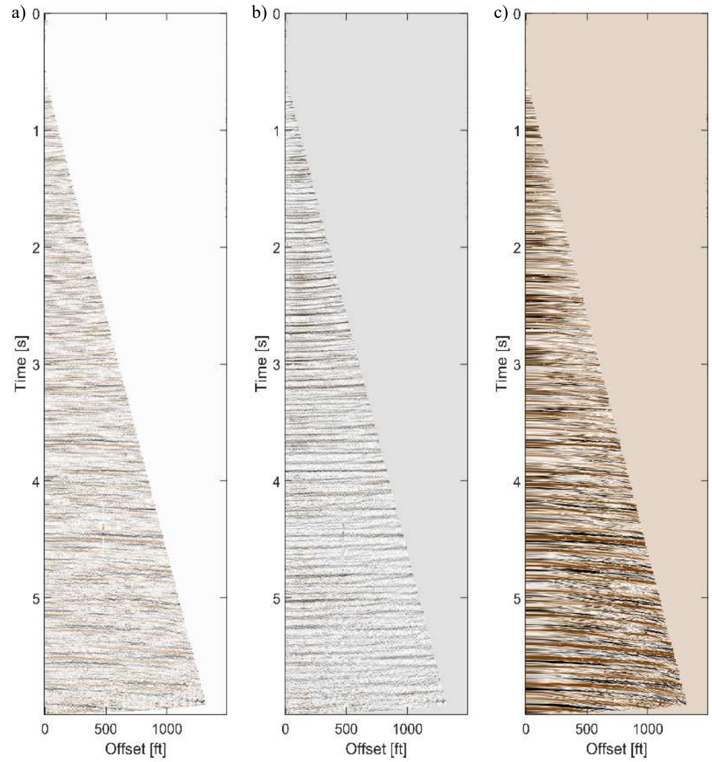

Figure 3.a) NMO corrected real marine data. b) Filtered data. c) Multiples

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