Adaptive attenuation of Ground roll – A case study from Western Onshore Basin

Jagannath Dash, S.S. Singh, P. L. Chamoli and Manav Kumar*
Western Onshore Basin, ONGC, Vadodara
Email ID: jd16642001@yahoo.co.in

Keywords

Adaptive, cross-spread, ground roll

Summary

Ground roll is the most persistent form of source generated coherent noise that obscures seismic signal and degrades the overall data quality. Most of the conventional ground rolls attenuation techniques use fixed parameterization and have limited success due to the rapid variability of near surface conditions. Finding an optimal method to attenuate ground roll has been a long goal in seismic data processing. The present study discusses the potential of a flexible approach of adaptive attenuation of ground roll. This data driven technique adapt to the changing noise characteristics and subtracts ground roll adaptively while preserving primary amplitudes. This method can be applied to attenuate ground roll in different domains, such as cross-spread or common shot/ receiver domain depending upon the data needs. The present study is based on application of this technique to raw 3D shot gather in cross spread domain. The efficacy of the process has also been compared with the conventional 3D FK filtering and it is observed that the present adaptive method has more potential to attenuates ground roll effectively and improves signal to noise ratio better.

Introduction

Ground roll is the major source of coherent noise in land seismic data. Ground roll arrives directly from source to receivers. It is characterized by low velocity, low frequency and high amplitude surface waves which are distributed at near offset around the source. The nature of ground roll changes from shot to shot and also within each shot. It can be highly dispersive, aliased and vary in terms of frequency, phase and group velocity and amplitude (Figure 1). So it is necessary to consider these spatial variations of ground roll during attenuation process. Over the last few years many algorithms have been developed such as FK approaches, HR Radon methods and wavelet transform to attenuate ground roll. But, these methods have their limitation because of irregular trace spacing, aliasing, changing characters of near surface and fixed parameterization. However, the process described here is purely a data driven approach to attenuate ground roll at true spatial position of shots and receives. Further, it can handle the rapid variation of near surface and adaptively subtract ground roll from the data.

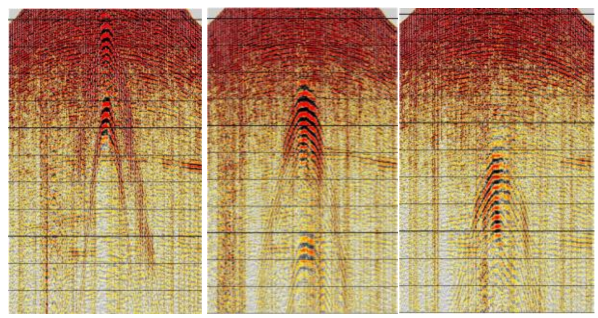


Figure 1: Variation in character and properties of Ground roll

Theory

The methodology is a data driven approach which estimates the characteristics of noise and signal from each gather. The data is splitted into several frequency sub-bands using a discrete wavelet transform and modeling is done in FX domain considering true positions of source and receiver. In each sub-bands, signal (S) is modeled as hyperbolic events whose trajectories are described by stacking velocity (V) as given in equation 1. The ground roll (GR) is modeled as a series of dispersive linear events, each distinguished by group and phase velocities as given by equation 2 (Le Meur et al 2008).

$$S^{j,k} = \exp[\, if\{ \mathrm{sqrt}(T_j^{\,2} + X_k^{\,2} / V_j^2) \}] \quad (1)$$

$$GR^{j,k} = \exp[i\{ (f_0/vp_j) + (f - f_0) / vg_j \} X_k] \quad (2)$$

For a j^{th} event T_0 is the zero offset travel time, X_k is the true shot receiver distance, f_0 is the central frequency of the wave and vp_j and vg_j are the phase and group velocities extracted from the input data. These events form the components of a matrix A with column and row indices j and k. In the frequency domain the input data can be represented by a matrix D as described by equation 3 (Le Muer et al 2008). A is the matrix that contain hyperbolic and dispersive linear events. W is a vector containing an unknown wavelet corresponding to the signal and ground roll plus some percentage of random noise N.

$$D = A * W + N \qquad (3)$$

A least square iterative approach is used to adapt this model to input data and ground roll is subtracted.

Examples

The adaptive method described in this paper is applied in cross-spread domain on a 3D seismic data volume acquired in orthogonal geometry in Western Onshore Basin. Orthogonal geometry can be considered as a collection cross spreads (Vermeer, 2002) in which each intersection of a source line and a receiver line forms the center of a cross-spread. The mid points of traces with same absolute offset are located on a circle with diameter equal to that of offset. Therefore, first arrivals of the ground roll lie on the surface of a circular cone. Hence, ground roll in a cross-spread behaves as a truly three dimensional event. A representative cross spread layout from the volume under study is shown in Figure 2.

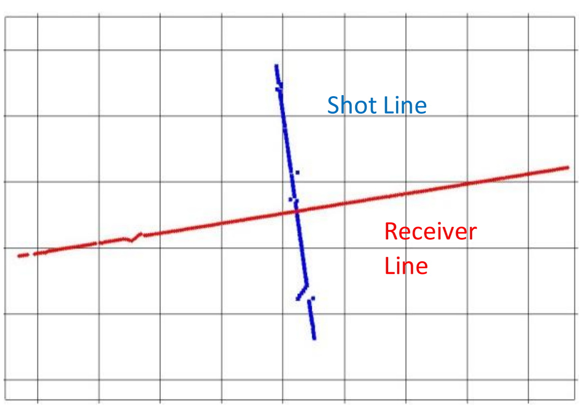
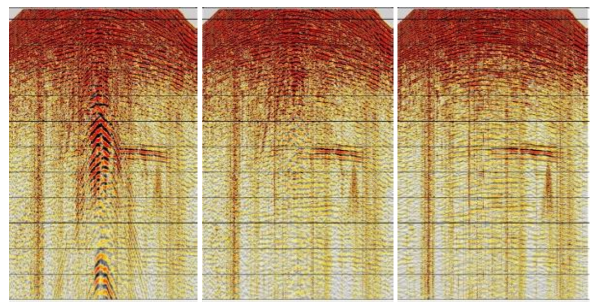


Figure 2: A cross- spread layout

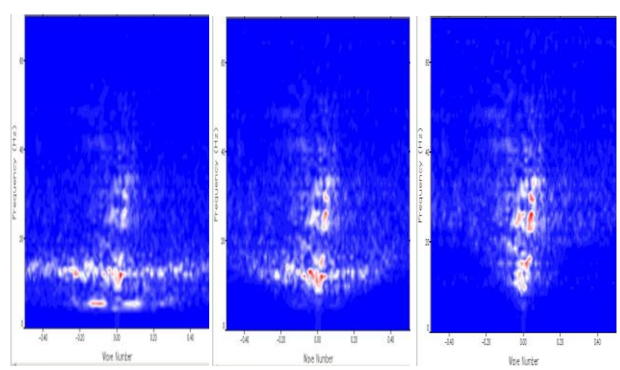
Processing has been carried out using Geovation software of CGG. To test the efficiency of the adaptive process, 3D FK filtering is also applied on the same dataset in one cross-spread for comparison and the results are shown on shot gather in Figure 3.



A B C

Figure 3: Comparison of shot gathers A- input, B- 3D FK, C- Adaptive method

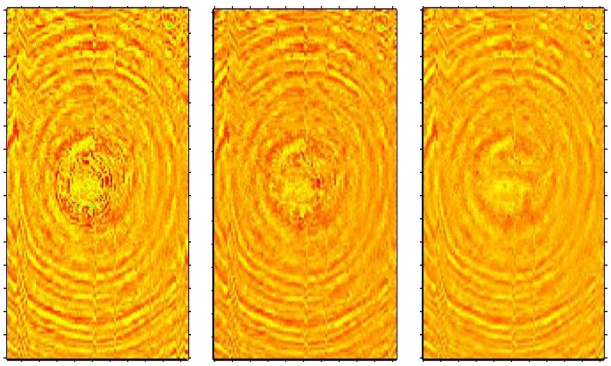
It is evident from this figure that ground roll is well attenuated by the adaptive method (Fig. 3C). In contrast, some remnant noise still exists after application of 3D FK filtering (Fig. 3B). A close look of the gathers reveals that the hidden reflection events, which are masked by the ground roll, are brought out more clearly after application of adaptive technique. To substantiate the results further, comparison of FK spectrum is shown in Figure 4.



A B C

Figure 4: Comparison of FK spectrum A- Input, B- 3D FK, C- Adaptive method

It can be easily inferred from the FK spectrum that ground roll which appears near the horizontal axis in the input data (Fig. 4A) is better attenuated by the adaptive method. Moreover, the signal to noise ratio has also enhanced considerably in this process. The effectiveness of the adaptive method can also be assessed again by looking at the cross-spread time slice in Figure 5.

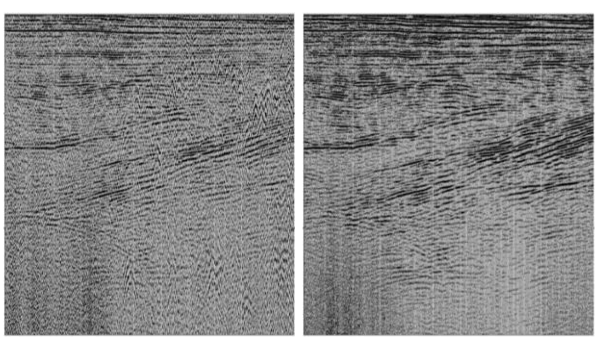


A B C

Figure 5: Cross- spread Time slice at1600ms
A- Input, B- 3D FK, C- Adaptive method

It is seen that the central part in the input data looks noisy (Fig.5A) due to contamination by the ground roll. After 3D FK filtering (Fig.5B) ground roll is partially removed but it is better attenuated after application of adaptive process (Fig.5C) and the events clarity is brought out excellently.

The adaptive method discussed above is then applied to the whole data volume and the result in stack sections is shown in Figure 6.



Before After

Figure 6: Ground roll attenuation in stack section

It can be clearly seen from the stack sections in Fig. 6 that the ground roll has been effectively removed. The stack section looks clean and the reflection events become more pronounced after ground roll attenuation.

Conclusions

From our above study it can be inferred that adaptive method addresses the issue of ground roll attenuation in an effective manner. The strength of this process lies in the fact that it is a data driven statistical method and noise characters are estimated from each input gather unlike fixed parameterization like dip cut offs and velocity. Finally, an important benefit of this technique is its application in different domains depending upon the acquisition geometry and data needs.

References

Anstey, N., 1986, Whatever happened to ground roll? The Leading Edge, 5, 40-46

Cary Peter and Zhang Changjun, Ground roll attenuation via SVD and adaptive subtraction, 2009, CSPG CSEG CWLS convention, 1-4

Karagul, A., Crawford, R., Sinden, J., and Ali, S., 2003, Recent advances in 3D land processing: Example from the Pakistan Badin area, First Break, 22, September, 37-44.

Le Meur D., Benjamin N, Twigger L., Garceran K., Delmas L., and Poulain G, 2010, Adaptive attenuation of surface wave noise, first break volume 28, September 83-87.

Le Meur D., Benjamin N, Cole R., Al Harthy M., Adaptive ground roll filtering, 2008, 70th EAGE conference & exhibition, Expanded abstract.

Vermeer Gijs J.O., Processing orthogonal geometry- what is missing? 3DSymSam – Geophysical Advice, Oldemarkt, The Netherlands.

Acknowledgements

The authors are thankful to ONGC for providing infrastructure to carry out this work. The authors are thankful to Shri A. V. Sathe, ED- Basin Manager, WON Basin,Vadodara for giving permission to publish this work. Thanks are due to Shri U.S.D. Pandey, ED-CGS, Mumbai and Shri S. N. Panigrahi, GGM-HGS, Vadodara for their keen interest in this work. Thanks also go to Shri B.K. Barve, GM-I/c 3D3C for his valuable guidance and suggestion during this work. Last but not the least, thanks are also due to all the members of 3D-3C group who are directly or indirectly involved in the analysis of the data.

The views expressed in this paper are solely of the authors and do not reflect the views of the organization which they belong to.