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Reliable Decon Operators for Noisy Land Data

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SUMMARY

Interbed multiples for noisy land data that survives the stacking process can be successfully deconvolved when operators are designed on NMO'ed and cleaned versions of the traces but are applied to NMO'ed original traces. Clean traces can be obtained by radial mixing NMO'ed (or differential NMO applied) traces in any domain where there is spatially dense distribution of traces.

Summary

Land 3D data is historically very noisy causing various signal enhancement problems. Single trace deconvolution, in particular, fails to obtain a reliable estimate of the multiples on such noisy traces causing ineffectively deconvolved results. Here we introduce a method of reducing noise from input traces before deconvolution operators are designed. As post- NMO stacking is used for this procedure we call this process a post stack driven prestack deconvolution method (abbreviated as PPDEC from here on). In this paper we describe the method and give examples of successful deconvolution applications. We also show that the Radial mixing operation (inherent in the PPDEC method) for deconvolution design can also be used as a powerful noise attenuation algorithm, which we call Radial Mix.

Introduction

Noisy land data has traditionally been difficult to interpret due to loss of resolution as well as the presence of ineffectively deconvolved multiples. It has recently been reported (Schjolberg et al, 2008) that reprocessing by using the PPDEC method has allowed successful interpretation of data from Oman leading to the discovery of oil. Gulunay & Benjamin explains (2008) the PPDEC method in detail. Here we summarize the idea behind the PPDEC method and show a few applications to field data. We also illustrate the use of radial mix alone as a noise reduction tool.

Field data and shot array forming via radial mix

The data we use to illustrate the method has been recorded as part of a wide azimuth land survey leading to high fold common receiver gathers. The common receiver domain provides a dense areal distribution of shots and this domain is therefore suitable for various noise reduction schemes before deconvolution. Shot x-y coordinates of part of such a common receiver gather are shown in Figure 1. In this domain, and for each input trace, (post NMO), one can find all of the traces within the neighbourhood of the trace (say within a circle of radius R, typically being less than one hundred meters) and stack them to reduce noise on them (and hence obtain a much better estimate of the primary and multiple amplitude relationship). The result of this process is cleaned up traces from random as well as steeply dipping coherent noise. As can be expected from Figure 1 this is a shot array forming process and is complimentary to short areal shot arrays that are used in current land acquisition systems. Deconvolution operators can now be designed from these improved S/N ratio traces instead of the noisy input data. During this process it is important to allow offset varying deconvolution parameters such as gap, effective operator length and white noise since NMO stretch is present on the traces before deconvolution. To summarise, the noisy traces are deconvolved with more correct and hence more effective operators to produce the deconvolved traces.

The effect of this process on stacked sections are shown in Figures 2,4, and 6 where stacks with no deconvolution (Figure 2) are compared to stacks with single trace decon (Figure 4) and with PPDEC (Figure 6). The corresponding autocorrelations for these stacks are shown in Figures 3,5, and 7. It is clear that ringing present in the stack with no decon (Figure 2) is somewhat suppressed by single trace decon (Figure 4) but is much more effectively suppressed by PPDEC (Figure 6). Comparison of stacks after PPDEC with the stacks after other deconvolution methods than single trace decon (e.g. as tau-p decon) also illustrated us (not shown here) the power of PPDEC in suppressing difficult multiples. Additionally it has been observed in many areas that the use of PPDEC provides greatly improved seismic to well matches as illustrated in Figure 8.

We show in Figures 9-11 the effect of the radial mix on steeply dipping noise. It is clear from these images that the process is signal preserving to a large degree. Another example of radial mix process is illustrated in Figure 12. Figure 12a shows an inline of a common receiver gather of some OBC data. On this record some ground roll and strong direct arrivals from the source exist. In Figure 12b we show that the direct arrival is attenuated to a large degree by

LMO with water velocity and a 2D inline F-K filter which is followed by 3D F-K filter for ground roll attenuation. Some direct arrival still survived the process. Figure 12c shows the result of radial mix done on this data which clearly suppressed the remnant direct arrival. The difference between input and output of radial mix process is given in Figure 12d showing again that the process is signal preserving to a large degree. The effect of the process on continuity of events is clearly illustrated by comparing a stack of the data with just ground roll attenuation (Figure 13) and with ground roll attenuation followed by radial mix (Figure 14) in a structurally complex area.

Conclusions

Multiples on noisy wide azimuth land data can be more accurately modelled and suppressed when deconvolution operators are designed from noise reduced versions of the original input traces but then applied to the original traces. Application of such a method has been proven on many occasions to effectively suppress multiples and provide greatly improved seismic to well matches. The radial mixing operation that produces these noise reduced traces also seems to be a powerful method for attenuating steeply dipping noise which otherwise leaks into stack volumes. With further refinement to the method it will become standard practice on modern wide azimuth surveys which have an excellent aerial coverage of source locations. As the method is both offset and azimuth preserving it is particularly suited for this purpose.

Acknowledgments

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References

Gulunay, N. and Benjamin, N. (2008) Poststack Driven Prestack Deconvolution (PPDEC) for Noisy Land data and Radial Trace Mixing for Signal Enhancement, Expanded Abstracts, 78th Annual Meeting of SEG.

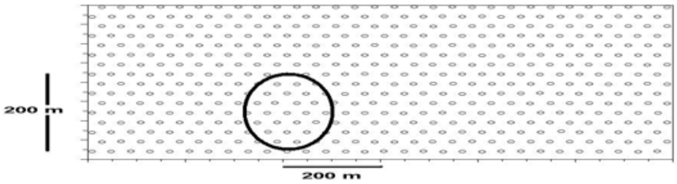

Figure 1 Shot coordinates of common receiver gather.

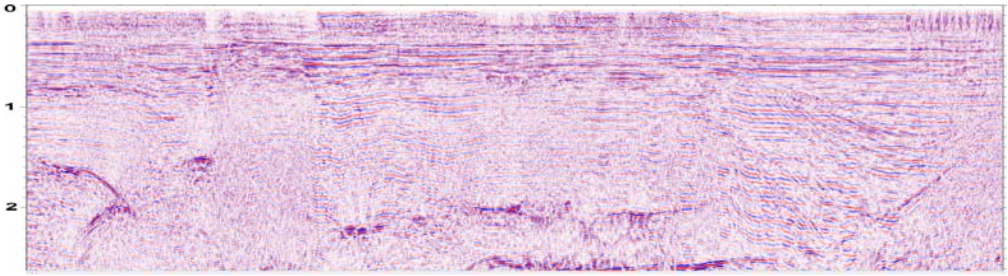

Figure 2. Stack with no deconvolution.

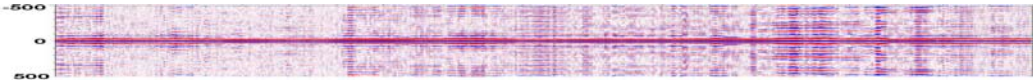

Figure 3. Autocorrelations from stacked traces with no deconvolution in Figure 2.

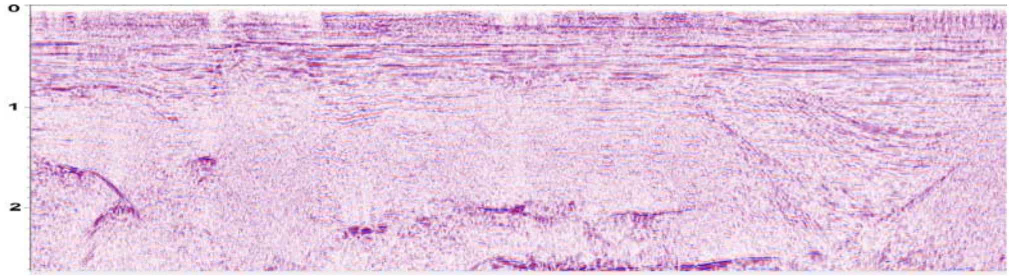

Figure 4. Stack with single trace gapped deconvolution.

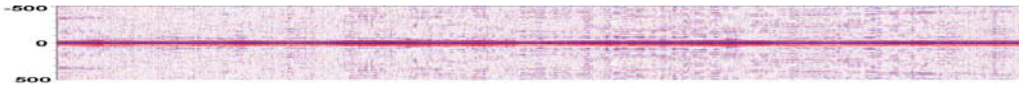

Figure 5. Autocorrelations from the stack of single trace gapped deconvolution in Figure 4.

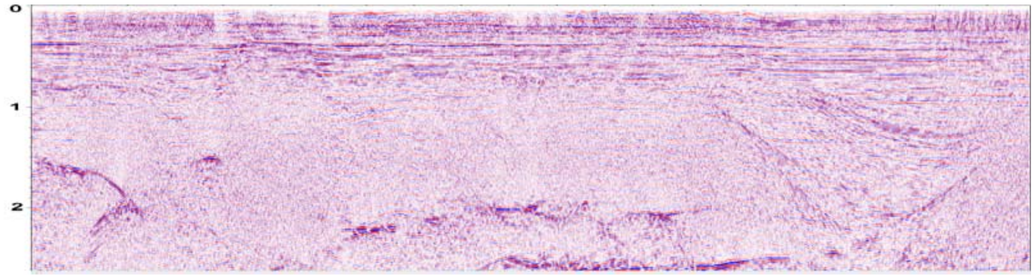

Figure 6. Stack after PPDEC.

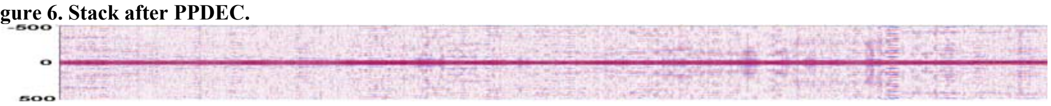

Figure 7. Autocorrelations of stacked traces after PPDEC in Figure 6.

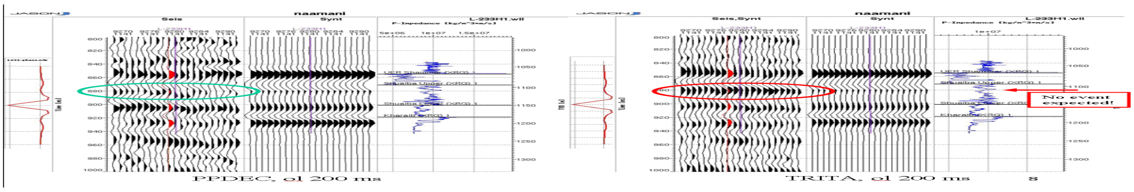

Figure 8. Improved seismic to well match provided by PPDEC (left) versus single trace deconvolution (right).

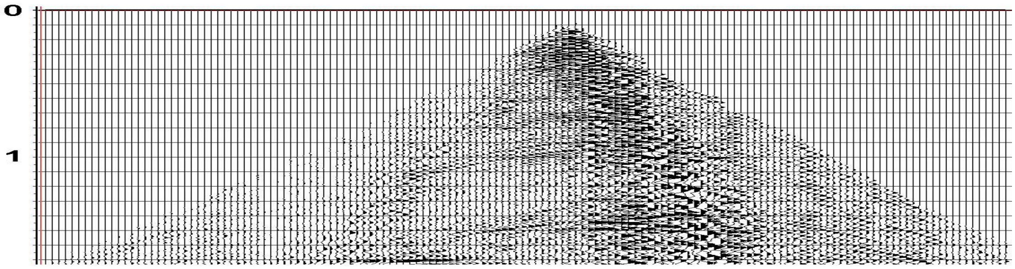

Figure 9. An input record after ground roll suppression.

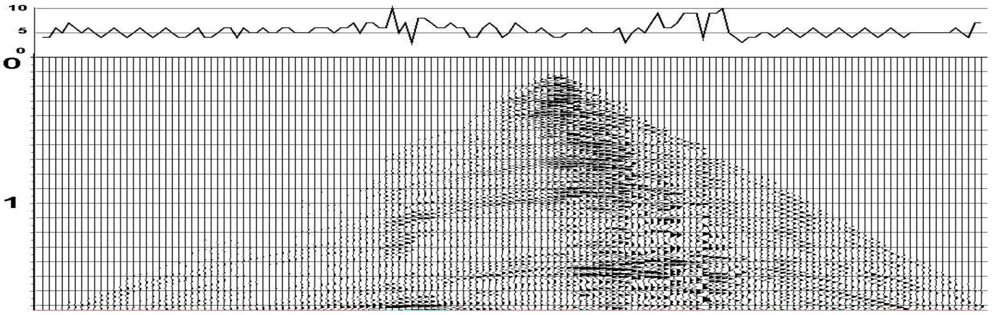

Figure 10. The same record as Figure 9, but after radial mix. The head-plot shows the fold of the radial mix. Irregularities in the fold are caused by irregularities in the surface distribution of shot locations.

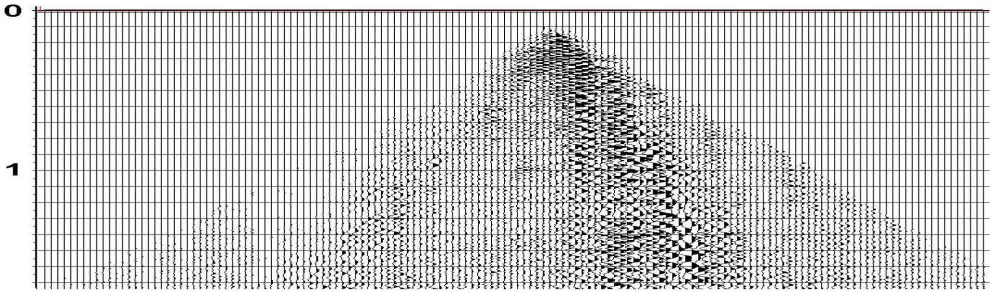

Figure 11. The difference between Figures 9 & 10, before and after radial mix.

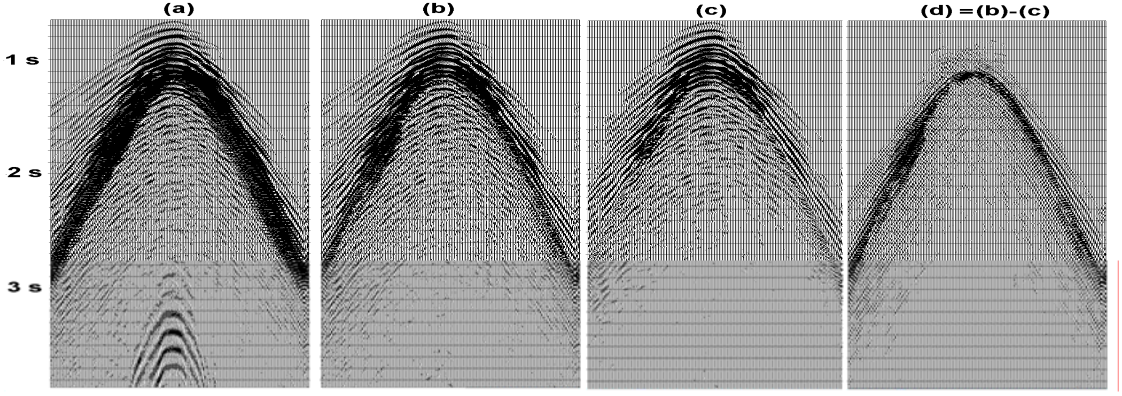

Figure 12. (a)-An inline record from an OBC common receiver gather, (b)- same record after direct arrival and ground roll attenuation, (c)- record in (b) after radial mix,(d) the difference between input and output of radial mix process.

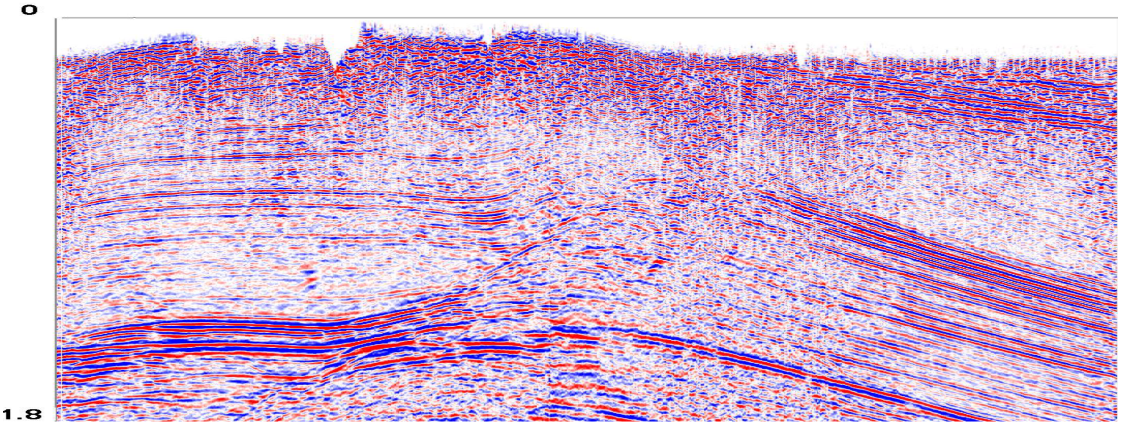

Figure 13. Stack from a structurally complex area (after ground roll attenuation).

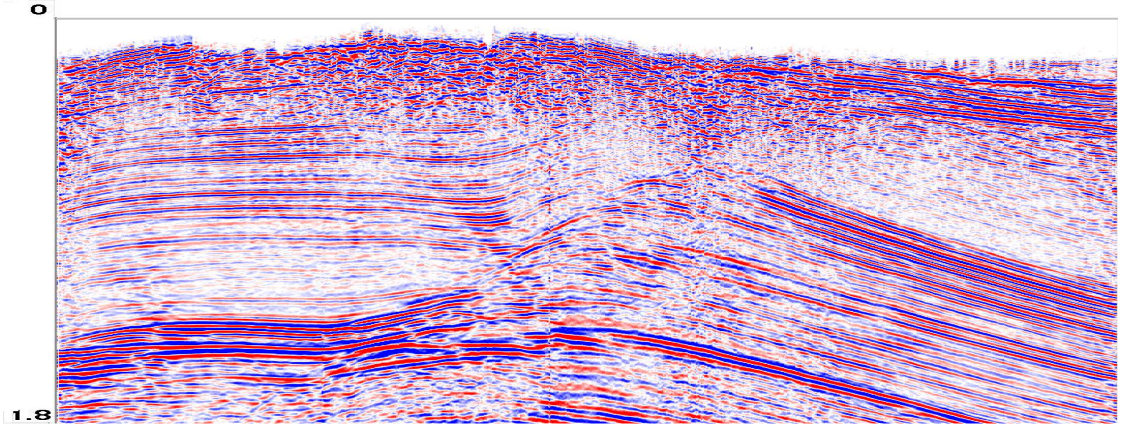

Figure 14. Stack after ground roll attenuation and radial mix.