Stanford Exploration Project, Report 112, November 11, 2002, pages 137–141

Short Note

Deconvolving passive data

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INTRODUCTION

Deconvolution prior to autocorrelation processing for a passive seismic data set has the potential to ameliorate wave-parameter and azimuthal inconsistency of arriving energy during acquisition. If any particular subset of plane-wave energy dominates the passive recording sequence, full illumination of the model-space may not be achieved. Further limitation of the result could also arise from the fact that the bulk of the ambient energy recorded in the experiment will likely be ground-roll energy that does not probe the subsurface. Thus, damping over-represented energy components by convolving the data with a prediction error filter (PEF) prior to processing/migration could serve to mitigate these short-comings of the experimental design.

To address the first problem of wave-number and azimuthal inconsistency, Artman (2002) suggests a trace balancing scheme after transformation of the raw data into (ω, p)-space. Convolution with a PEF instead will also produce this result.

EXPERIMENT

To explore the feasibility of this idea, we used the solar data set that has been seen in several previous reports. The frequency content of this data shows two distinct modes as seen in Figure 1. The previous results generated by autocorrelation processing (Rickett and Claerbout, 1999) used a low-cut version of the data that removes the energy below 2 mHz. Figure 2 is a comparison of three different inputs to the autocorrelation processing algorithm. The right panel uses the raw data. The center panel uses a low-cut version of the data. The left panel is the output after 1-dimensional deconvolution. Unfortunately, a small amount of DC noise has survived the deconvolution process. Because the solar data is not quite as stationary as had been hoped, estimating the PEF on too small an area resulted in an output spectrum that is not white in all locations. Some color left in the frequency content of the result would seem acceptable; however, the low-frequency contribution to the result presents a problem in the auto-correlation processing.

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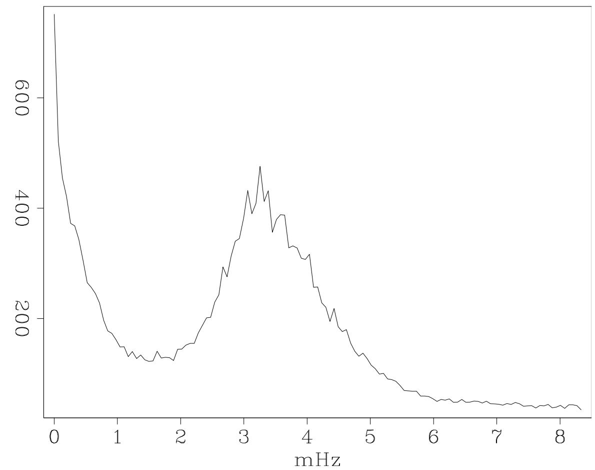

Figure 1: Frequency content of the passive solar seismic data set. Data are sampled in Kilo-seconds yielding milli-Hertz frequencies. brad2-spec [CR]

To better combat this near-D.C. component of the data, all of the traces were passed through a 1D gradient operator. Having thus removed the low-frequency component of the data, the PEF estimation and convolution process was performed again followed by auto-correlation processing. Figure 3 shows the result of this processing scheme. The result is better focused, crisper and more pleasing than the results shown in Rickett and Claerbout (1999) generated by low-cut filtering and auto-correlation processing.

The first in-line section of the result of this processing chain is shown in Figure 3 and seems to show three faint events that have not been previously identified. Unfortunately, further evidence to corroborate them as real events have not been fruitful. Perpendicular sections do not reveal similar events. Time slices do not show circular horizon intersections. Finally, an azimuthal stack around the central trace was calculated. Figure 4 shows this result with no indication of the earlier events.

CONCLUSION

Deconvolution of a passive seismic dataset has been shown to produce sharper, more crisp output. By balancing the energy recorded in an experiment arriving around all azimuths and from all incidence angles is an important first step in the passive seismic imaging experiment.

One-dimensional deconvolution of the solar passive seismic dataset proves to be a quick and advantageous step prior to auto-correlation processing to produce a sharper result. The assumption that the solar data are approximately stationary, however, is flawed and results in inadequate representation of the entire body of the data when a PEF is estimated on a small part of the data. By operating instead on the gradient of the raw data, this problem is greatly reduced as the major problematic remnant in the raw data deconvolution was a large low-frequency component.

Processing the solar data in this manner may have uncovered a previously undiscovered and possibly directionally propagating event. Conversation with the solar physicist are underway in hopes of identifying what type of physical phenomenon these could be. Two-

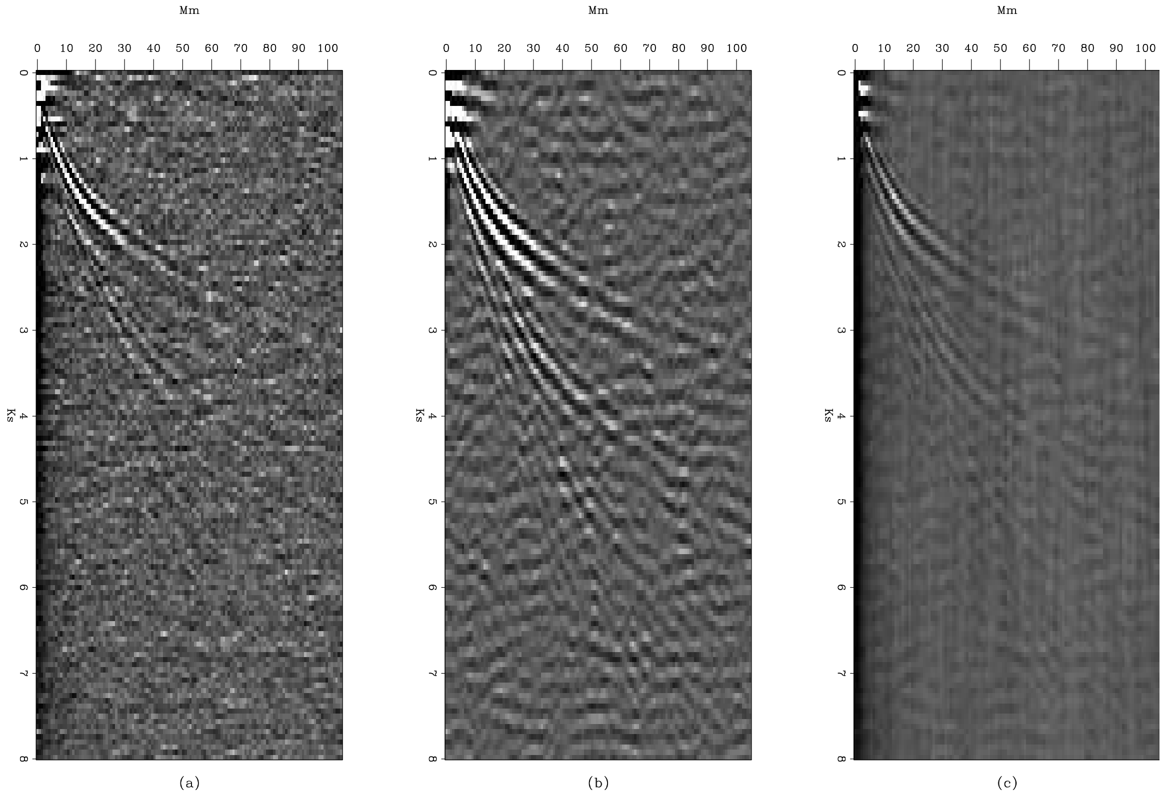

Figure 2: Left panel is autocorrelation after deconvolution. Center panel is processing after low-cut filter. Right panel is produced using the raw data. brad2-three [CR]

dimensional deconvolution and work on a larger, longer similar data set may prove fruitful in the near future.

ACKNOWLEDGMENTS

We would like to thank the SOI/MDI project at the Stanford Physics Department for donating this dataset and one to come. Thanks also to James Rickett on whose shoulders this work progresses.

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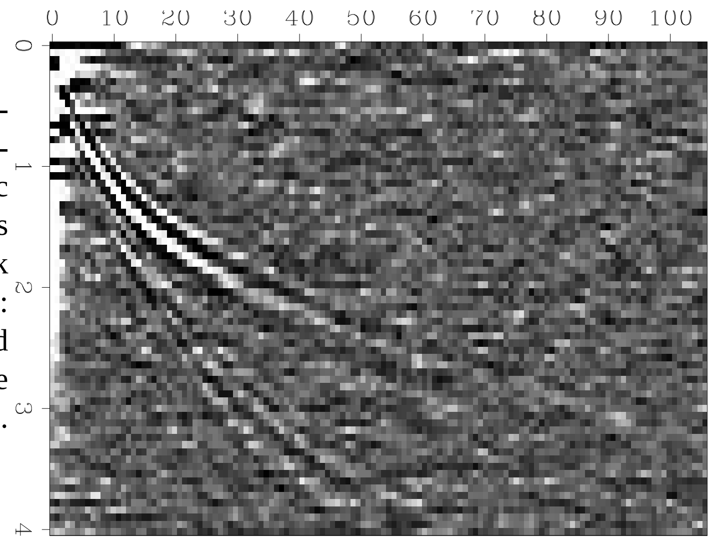

Figure 3: After 1D gradient, deconvolution, and auto-correlation processing the solar passive seismic data may reveal faint new events on this in-line section. Look carefully for 3 dark linear events: from ($0Mm,0ks$), ($10Mm,0ks$), and ($40Mm,0Ks$). The velocity of these events is approximately $50,000m/s$. brad2-newevent [CR]

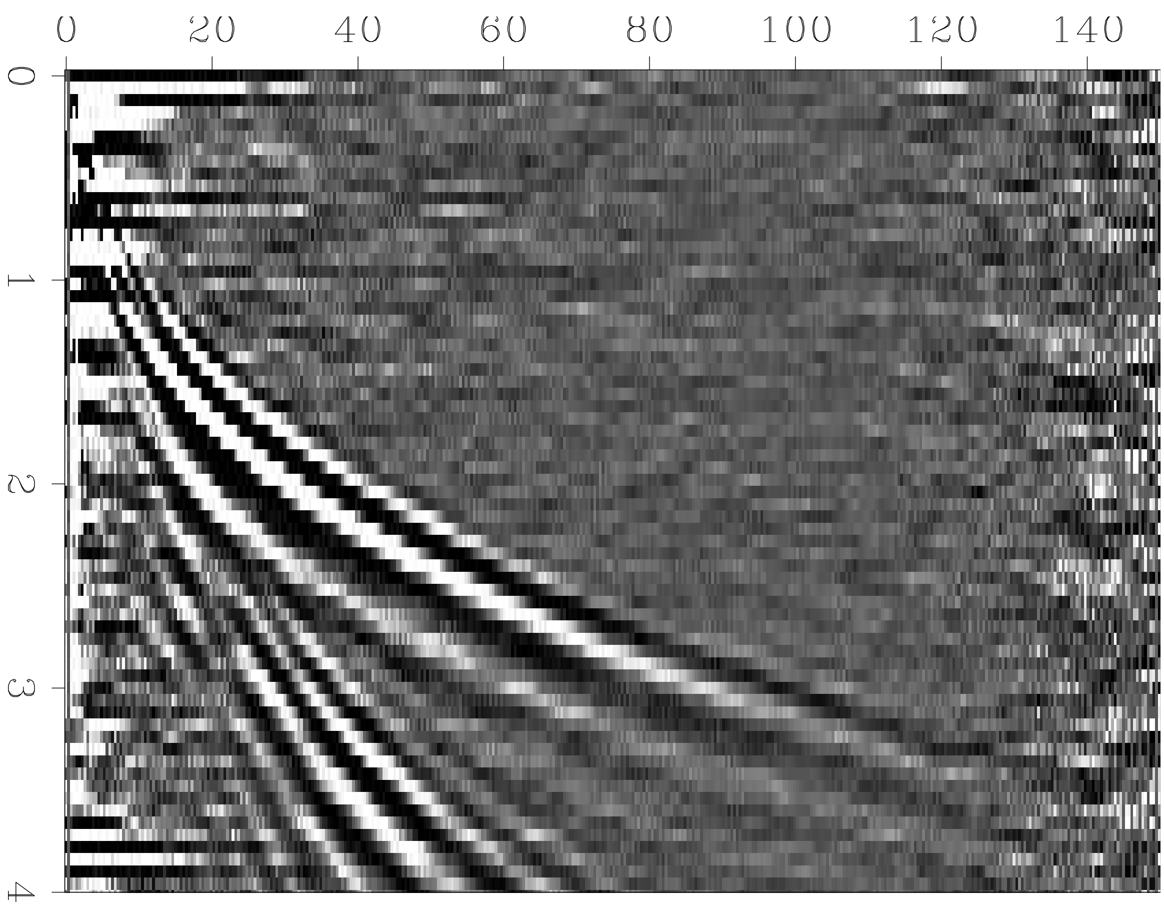

Figure 4: Radial stack of previous data to see if the "events" might stack into reality. No further evidence of the events. brad2-radstack [CR]