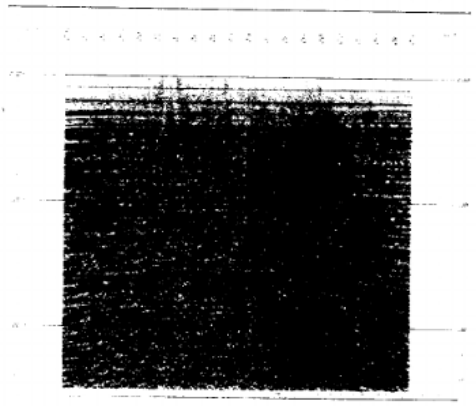

FIG. 1. Stack without noise filter.

$$U(t, x) = \sum_{j=1}^{N} V_j[t - g_j(x)]$$

for the (t,x)-domain, and

$$U(\omega, x) = \sum_{j=1}^{N} V_j(\omega)e^{-i\omega g_j(x)}$$

for the (ω, x)-domain where $V_j(t)$ is the arbitrary wavelet associated with each event, and $V_j(\omega)$ is their respective Fourier transform.

For the linear model the last equation becomes

$$U(\omega, x) = \sum_{j=1}^{N} V_j(\omega)e^{-i\omega b_j x},$$

showing once more that the model suggests purely sinusoidal complex functions.

Complex Wiener filtering

The above section shows that our model for the signal is made by summing complex exponentials of the spatial variable x. Appendix A shows that the signal is also characterized by the fact that it is predictable with a one-step-ahead convolutional prediction filter.

The predictable character of the signal permits us to use the "complex prediction Wiener filter theory" to estimate a least-squares approximation of the predictable part of $U(\omega, x)$ for each particular frequency ω. A transformation back to the (t, x)-domain yields the desired enhanced section.

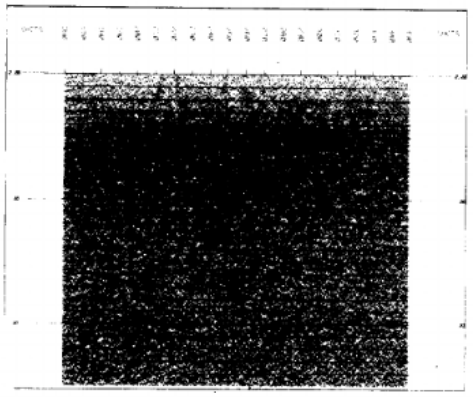

FIG. 3. Noise removed with one pass of noise filter.

Applications

Figure (1) shows a seismic section of land data. The section is clearly contaminated by random noise. Figure (2) shows the same data after the random noise has been attenuated. The improvement is very significant. Note that the process does not create events nor does it produce a mixed appearance. Figure (3) shows the noise that was removed from the data, its randomness is very reassuring as it shows that we are not removing coherent events.

Finally, Figure (4) shows the same section after two applications of the process, yielding an extra improvement. The section was balanced between applications to account for amplitude reduction in the noisy areas.

Conclusions

We have presented a method for reducing random noise in seismic data. It was developed as a linear prediction problem in the (ω, x)-domain, so that Wiener filters could be easily implemented. The potential of the method is quite remarkable. The results show the method to be successful in attenuating the random noise in seismic data without producing any noticeable lateral mixing.

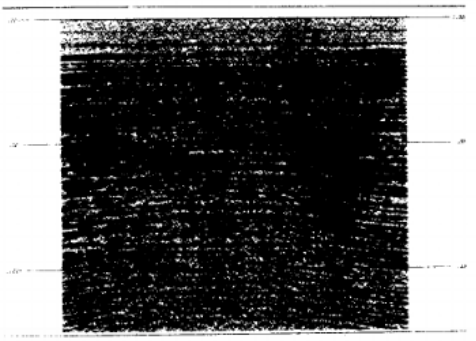

FIG. 2. Stack with one pass of noise filter.

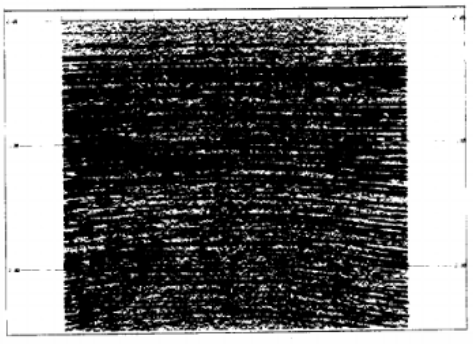

FIG. 4. Stack with two passes of noise filter.