Random Noise Reduction S10.1

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We present a method to reduce incoherent noise from seismic data. The signal is defined in terms of a simple model that separates the time and space variables so that the signal is formed by a sum of complex exponentials in the (ω, x)-domain. For a given frequency, we show that the signal is predictable as a function of x. We then use the Wiener filter theory to obtain a least-squares approximation of the underlying signal. The method has been tested on noisy data with very good results, the removed noise is of random appearance and the method does not produce the synthetic appearance common in many mixing schemes.

Theoretical development

Our starting model is a trace ensemble $U(t, x)$ that is composed of delayed impulses as defined by:

$$U(t, x) = \sum_{j=1}^{N} A_j \delta(t - g_j(x)),$$

where a_j is the arbitrary coefficient representing the strength of the N impulse, and $g_j(x)$ is the delay function that defines the shape of the events. After Fourier transformation with respect to time, the equation becomes:

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

where ω is the angular frequency. In the (ω, x)-domain, our model then turns out to be a sum of sines and cosines in which the argument is a function of ω and x.

Linear approximation

We now consider only events that are nearly linear with respect to x. That is, the functions $g_j(x)$ should be linear. The linearity requirement means that we need to consider subensembles of traces, so that events are nearly linear within the subensemble.

With the linearity assumption, our model equations are

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

where c_j is the complex constant that depends on the strength and bulk shift, and b_j is a measure of the events' slopes. The equation shows that under the linearity assumption, the function $U(\omega, x)$ is strictly sinusoidal in x.

Frequency-dependent model

The model illustrates the main idea of the method, but there is no reason to limit ourselves to impulsive events. We can assume the events have an arbitrary wavelet convolved with the impulses so that $U(t, x)$ becomes