Fundamentals of Wavelet Processing of Land Seismic Data, Part 2

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Abstract

The prestack wavelet processing flow that consists of surface-consistent deconvolution followed by some form of trace-by-trace spectral whitening is standardly used on Western Canadian seismic data, and it seems to produce final stacks with wavelets that are broadband and constant in phase, with little interfering coherent noise except where the fold becomes very low. The application of poststack spectral whitening to broaden the amplitude spectrum of the wavelet after stack (sometimes in a time-variant form) is common, and much appreciated, in some quarters, but is rarely done, and treated with much suspicion, in other quarters. The friends of poststack spectral whitening enjoy the higher-resolution stacks that it obviously produces while its foes argue that the higher resolution is just a side-effect of whitening the spectrum too much, and cannot be trusted.

In the continuation of this tutorial-style study, the effects of post-stack spectral whitening (in both time-variant and time-invariant forms) are examined in detail with the same set of synthetic seismograms with realistic noise as in Part 1. A flow that includes time-variant spectral whitening followed by f-x decon is shown to produce improved resolution, without any sign of harmful side-effects such as ringy wavelet side-lobes (Figure 1). On very noisy datasets, applying f-x decon first can improve the performance of the spectral whitening.

The results of Part 1 provide an understanding for why poststack spectral whitening is needed. The wavelets on the prestack traces after prestack spectral whitening have uneven frequency content: far-offset wavelets will likely have wider frequency bandwidth than the near-offset traces that are contaminated with shot-generated noise. We should therefore not expect the wavelet on the stacked traces to have a flat amplitude spectrum, even if the velocities and statics are perfect. Poststack spectral whitening is a way of retrieving the frequencies in the poststack wavelet that were selectively suppressed on some of the prestack traces by prestack spectral whitening. In addition, the better signal-to-noise ratio after stack allows the spectral whitening process to work more on signal in the poststack case than in the prestack case.

The final wavelet that is embedded in the stack for this synthetic example has a phase spectrum that is in error by almost 90°. It is not unusual to encounter this type of phase error when matching real seismic data to synthetic seismograms, nor should it come as a surprise once we understand the effects of noise on deconvolution.

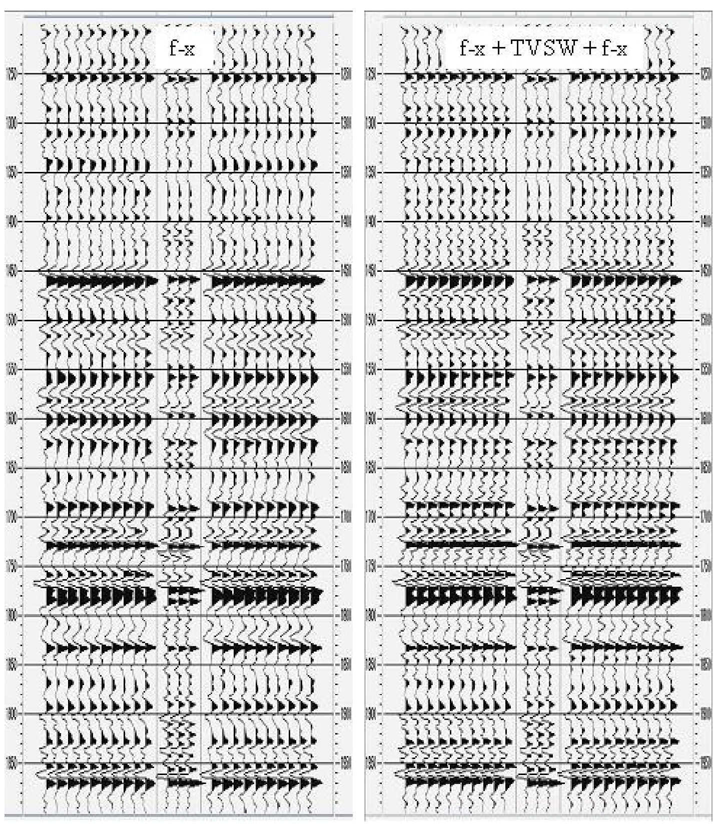

Figure 1. The events in the stack with poststack spectral whitening (TVSW) on the right match the correct stack (spliced into the centre of both stacked sections) better than the stack on the left without poststack spectral whitening.