

Intelligent design: the diagnostic mode of Gabor deconvolution

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ABSTRACT

The diagnostic power of various displays of the Gabor transform has long been recognized, and such displays can be very intuitively instructive. Accordingly, we have extended the latest version of our surface-consistent, iterative Gabor deconvolution module, `Gabor_sc`, to include an alternative, diagnostic mode. In this mode, the program yields Gabor spectra, output as seismic traces, which can be displayed using Trace Display in ProMAX, or any other suitable seismic trace display operation. We demonstrate this new diagnostic mode here and show four examples where it has already proved its usefulness: studying parameter sensitivity; deconvolution operator design; deconvolution algorithm fine-tuning; and vibroseis sweep design.

INTRODUCTION

From the earliest MATLAB-based incarnation of Gabor deconvolution (Margrave et al, 2001), through years of further development (Margrave et al., 2002a), (Margrave et al., 2002b), (Margrave et al., 2003), (Montana et al., 2006) displays of Gabor spectra of seismic traces have been instrumental in improving our intuitive understanding of the Gabor transform and its relation to a seismic trace. It has been useful, as well, in showing the relationship of the underlying Q-function, and in evaluating the various techniques used in wavelet estimation. When the first two ProMAX implementations of Gabor deconvolution were written, however, diagnostic plots were not included in the original coding, even as an alternate output option. As we continued to develop the latest surface-consistent and iterative version of Gabor deconvolution, `Gabor_sc` (Henley et al, 2007), however, it became apparent that easily generated diagnostic plots could be of significant use, not only for working with Gabor deconvolution, but as a separate diagnostic tool for analyzing seismic data in general.

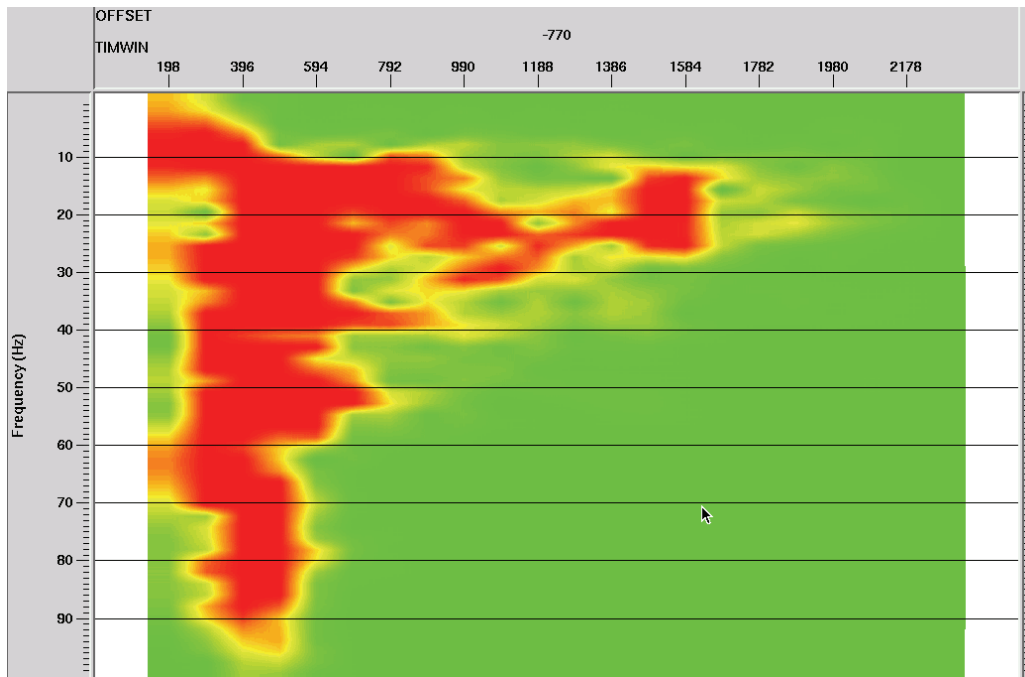
Finally, early in 2009, we modified the `Gabor_sc` code to include a diagnostic mode. Originally, we had planned to allow diagnostic Gabor spectra to be extracted from any stage of the original `Gabor_sc` algorithm and output as extra traces. The necessary bookkeeping became too cumbersome, however, so we chose, instead, to modify `Gabor_sc` to operate in one of two exclusive modes: either in its original iterative, surface-consistent deconvolution mode; or as a diagnostic program only, in which it simply computed Gabor spectra, Q-function, or residual Gabor spectra for whatever seismic traces were selected as input. In retrospect, the usefulness of the resulting module has vindicated our choice of the simpler design.

DETAILS

The new version of `Gabor_sc` contains 2 new parameters, supplied from the ProMAX pop-up menu: the mode switch, and the output selector switch. The default for the mode switch is to operate `Gabor_sc` in its normal surface-consistent and iterative mode. In this mode, the program requires a database corresponding to the input data set in order to set up its various storage arrays, and requires that the input data set be read at least twice by

setting the appropriate parameter on the 'Disk data input' menu. When the mode switch is set to '1', however, selecting the diagnostic mode, the program does not need large storage arrays and so does not look for a database. It also requires only a single pass through the input data. In this case, the 'Disk data input' parameters can be used to select which specific traces from the input data stream enter the diagnostic mode.

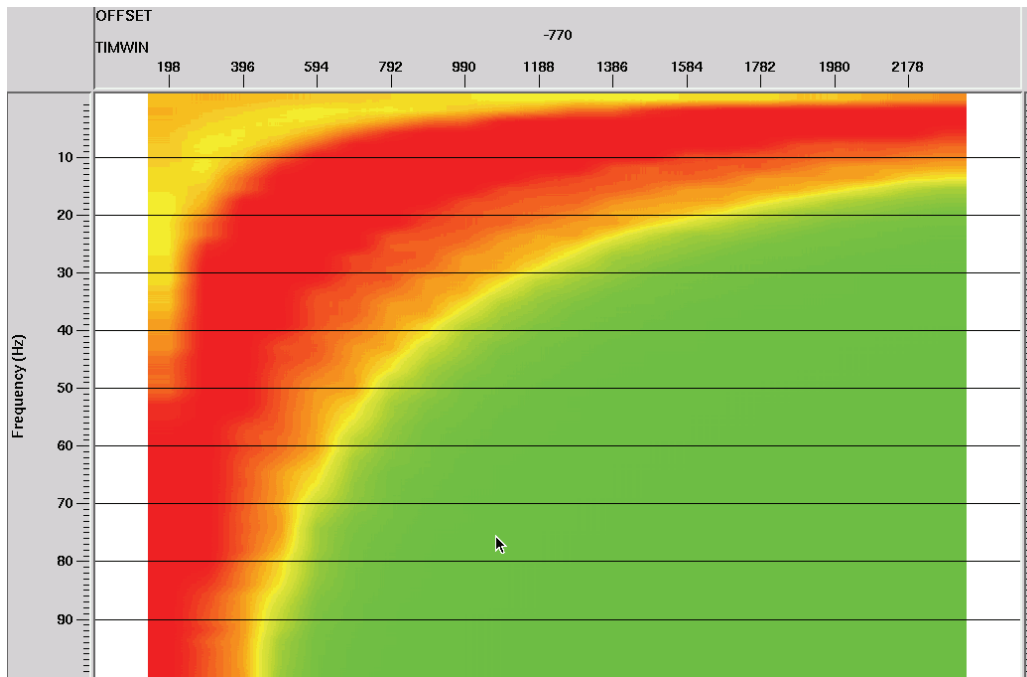
The output selector switch appears in the Gabor_sc menu only if the mode switch is set to '1', and it may have one of four values, 1, 2, 3, or 4, which determines which Gabor spectra are saved as output traces. When '1' is chosen (the default), each input trace selected by the 'Disk data input' parameters is transformed into the Gabor domain using the parameters on the program menu. The Gabor magnitude spectra are then placed into seismic traces for output; the frequency spectrum for each Gabor time window placed into one output trace, annotated with a new trace header, 'timwin', which contains the travel time of the centre of the corresponding Gabor window. Each seismic input trace thus generates an ensemble of frequency domain output traces, each trace corresponding to the magnitude spectrum of one window of the Gabor transform of the trace. The resulting ensemble, upon output, can then be plotted with 'Trace display' in color or grayshade density mode to show the complete Gabor transform of the input trace. The vertical scale of the plot is frequency, and if selected for plotting on the 'Trace display' menu, the horizontal scale will be 'timwin', which provides the time scale for the transform. Figure 1 shows the Gabor spectrum of a raw input seismic trace in the color density trace display mode. The appearance of this spectrum depends upon the various parameters in the Gabor_sc menu, including the width of the window, the window overlap, and the Lamoureux window parameters. In general, shorter windows provide greater time resolution, but less frequency resolution for the Gabor spectrum, while longer windows lead to greater frequency resolution, but less time resolution.



Raw Gabor magnitude spectrum of the input trace at -770 m offset—time window centre displayed along the top axis

FIG. 1. Gabor magnitude spectrum of raw seismic trace—option 1 for diagnostic mode of gabor_sc

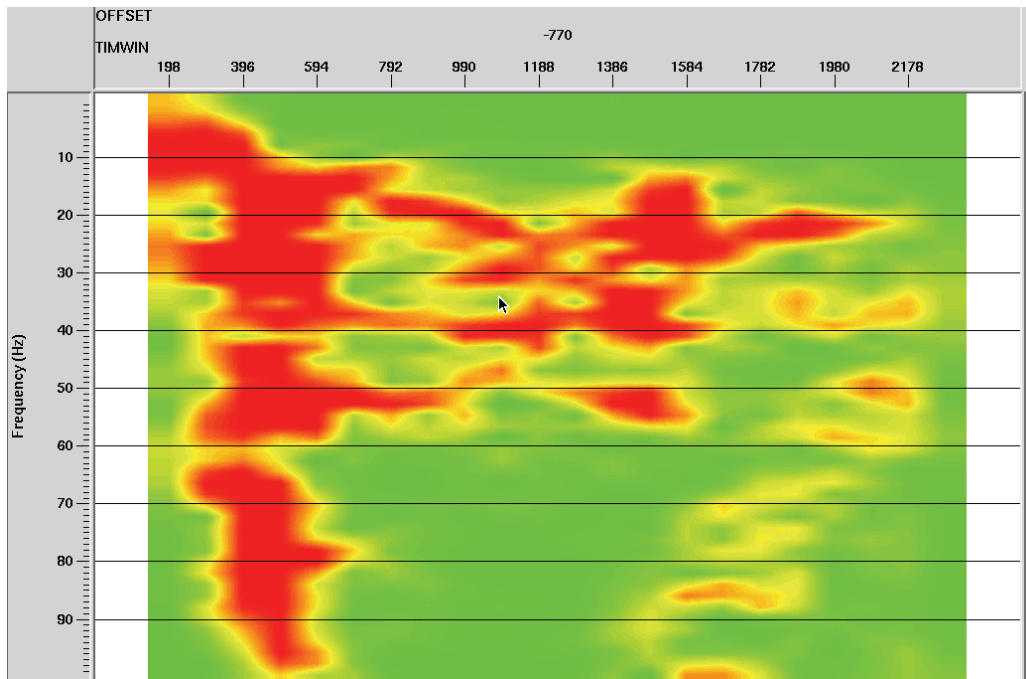
When '3' is selected for output, the Gabor_sc algorithm chooses its output from the subroutine which performs hyperbolic smoothing. This subroutine separates the raw Gabor spectrum into two components, the slowly varying Q-function, and the more rapidly varying residual, which is used, after smoothing, to estimate the wavelet spectrum. Hence, the Q-function is placed into an ensemble of output frequency traces, annotated by the 'timwin' trace header, just like the raw Gabor spectra for option '1'. Figure 2 shows the Q-function corresponding to the trace whose raw Gabor spectrum appears in Figure 1. The Gabor window parameters for this display are the same as for Figure 1, so the plots are completely comparable.



Q-function estimated for the trace at offset -770 m offset—time window centre displayed along the top axis

FIG. 2. Q-function extracted from raw seismic trace—option 3 for diagnostic mode of gabor_sc

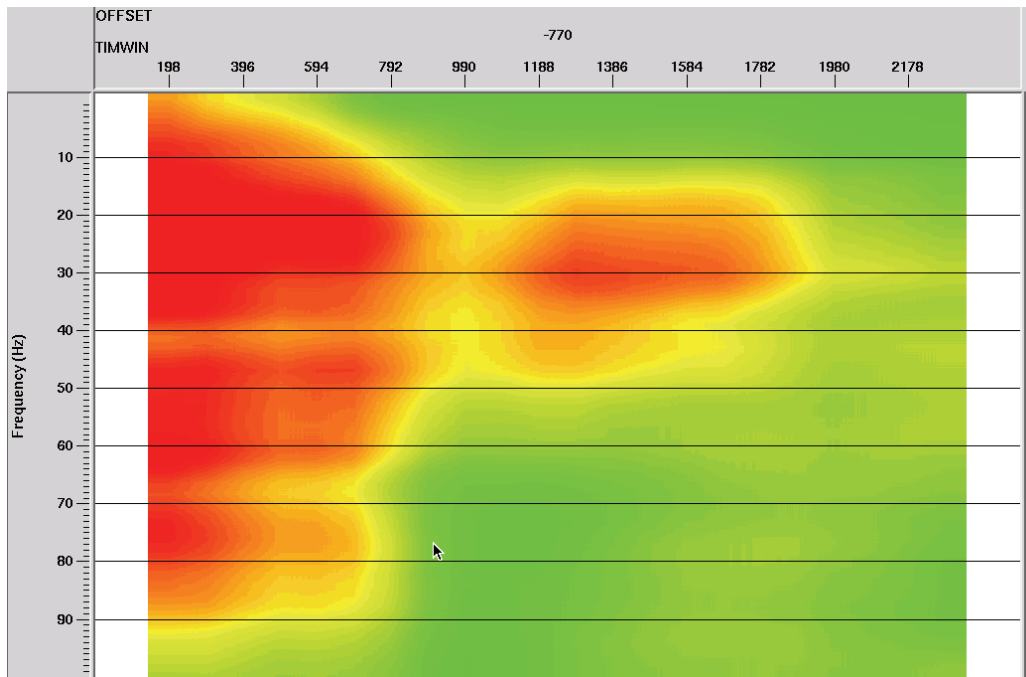
The selection of ‘4’ for output directs the program to choose the other output of the hyperbolic smoothing subroutine, the more rapidly varying ‘residual’. The resulting spectrum is then moved to the output ensemble, once again output as frequency traces with the appropriate ‘timwin’ trace headers. Figure 3 shows the ‘residual’ Gabor spectrum corresponding to the raw spectrum in Figure 1, after removal of the Q-function.



Residual raw magnitude spectra (after dividing by Q-function) for trace at -770 m offset—time window centre displayed along the top axis

FIG. 3. Residual spectrum after removal of Q-function in Figure 2 from raw spectrum in Figure 1—option 4 for diagnostic mode of gabor_sc

The wavelet estimate from Gabor_sc is the final option which may be displayed, this time by selecting '2' with the output selector switch. Here, the 'residual' spectrum from the hyperbolic smoothing subroutine is smoothed according to the parameters on the Gabor_sc menu, then output as an ensemble of frequency traces with the usual 'timwin' trace headers. Figure 4 shows the wavelet estimate spectrum corresponding to the residual spectrum of Figure 3.



Residual magnitude spectra smoothed to provide wavelet estimate for trace at -770 m offset—time window centre displayed along top axis

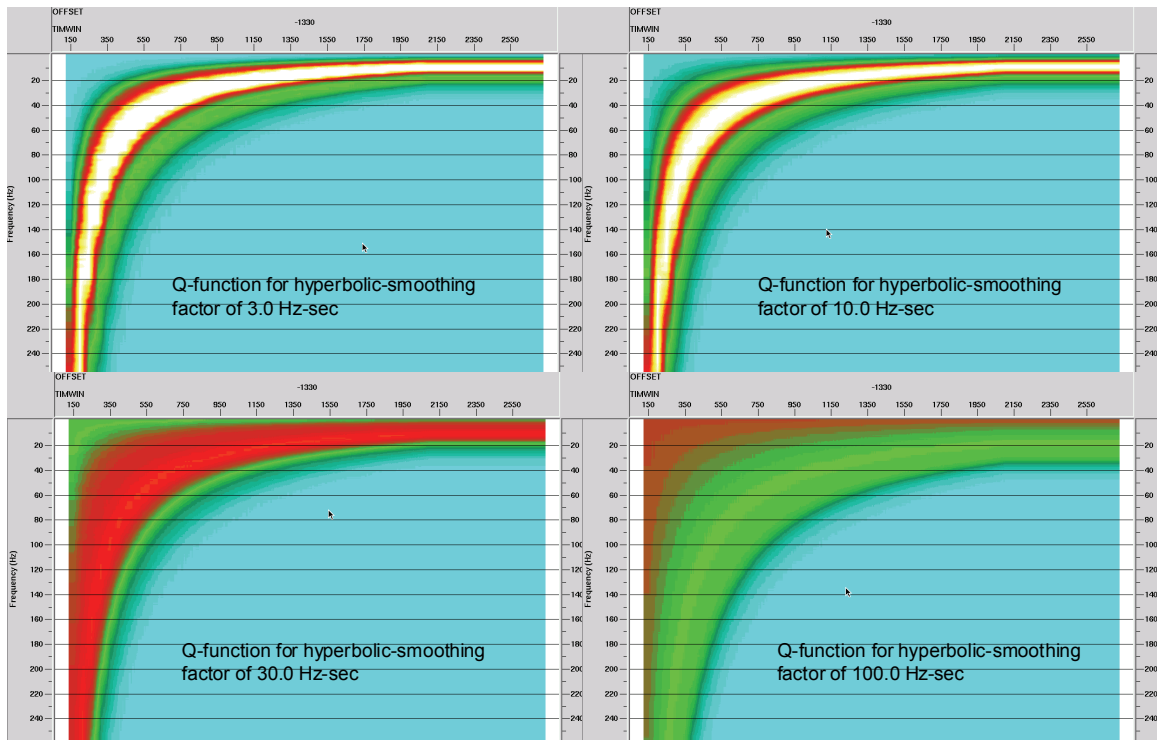
FIG. 4. Smoothed residual spectrum used as wavelet estimate for deconvolution of raw seismic trace

EXAMPLES

Much of what appears below may seem like obvious applications, but we present them in hopes of motivating users to regard deconvolution less as a ‘black box’ and more as a process with rational parameter choices.

Parameter sensitivity

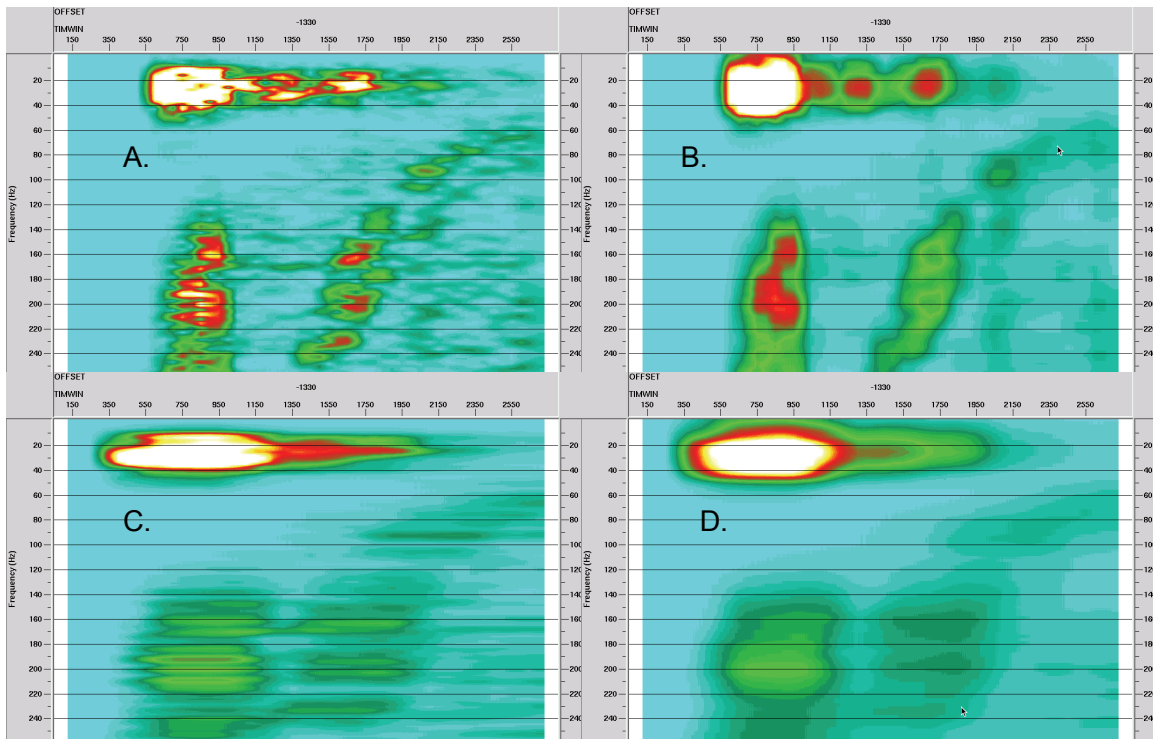
In the application of Gabor deconvolution, it has proven difficult to determine appropriate values for the various parameters, based solely on the appearance of seismic traces which have been deconvolved with the algorithm. One of the most difficult parameters to set is the smoothing scale value (in dimensions of Hz-sec) for the hyperbolic smoothing operation. While widely varying values seem to have little effect on output results, we have had no rational basis for selecting a ‘good’ value. Figure 5 shows plots of four different Q-functions computed for greatly different values of the smoothing parameter. It is immediately obvious that the smoothing is not very sensitive to the choice of this parameter; but it can also be seen that the value we have used as the default for several years (1 Hz-sec) is probably too small, in that the Q-function varies too rapidly across its contours, compared to the more desirable smooth function that results from a value in the 10-30 Hz-sec range.



Q-functions for hyperbolic smoothing factors of 3.0, 10.0, 30.0, and 100.0 Hz-sec

FIG. 5. Dependence of the Q-function on hyperbolic smoothing parameter

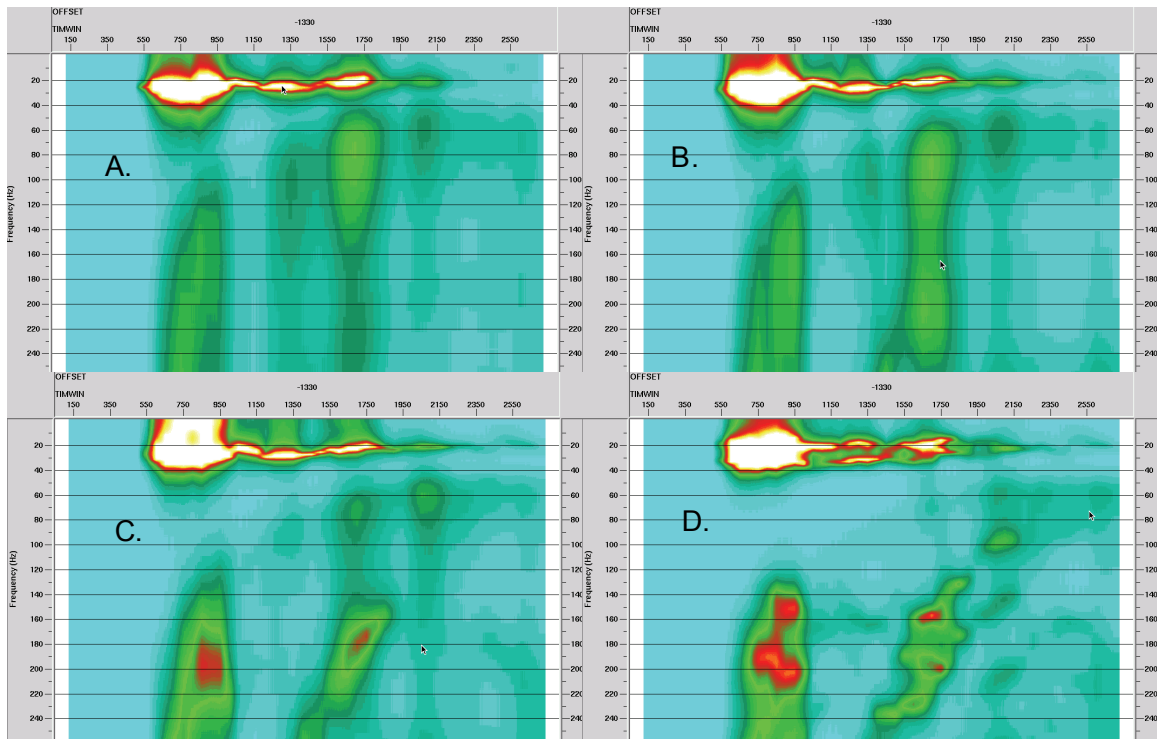
Figure 6 is a comparison of 4 different choices for frequency and time smoothing parameters for wavelet estimation from the same residual spectrum. In this figure, the effects of smoothing length are obvious. In the following section we show how the frequency smoothing length can be optimised for a particular deconvolution objective.



Residual wavelet spectrum—A. no smoothing; B. 30 Hz boxcar in frequency, no smoothing in time; C. No smoothing in frequency, 0.6 sec boxcar in time; D. 30 Hz boxcar in frequency, 0.6 sec boxcar in time

FIG. 6. Comparison of different amounts of smoothing in frequency and time of the wavelet estimate spectra

Since the Gabor_sc algorithm, like its companion module Gabor2, offers the option of using Burg spectra for wavelet estimates, we show in Figure 7 the wavelet spectra estimated using four different combinations of Burg coefficients. Once again, diagnostics like this should be useful to the processor wanting to explore various wavelet estimation alternatives.

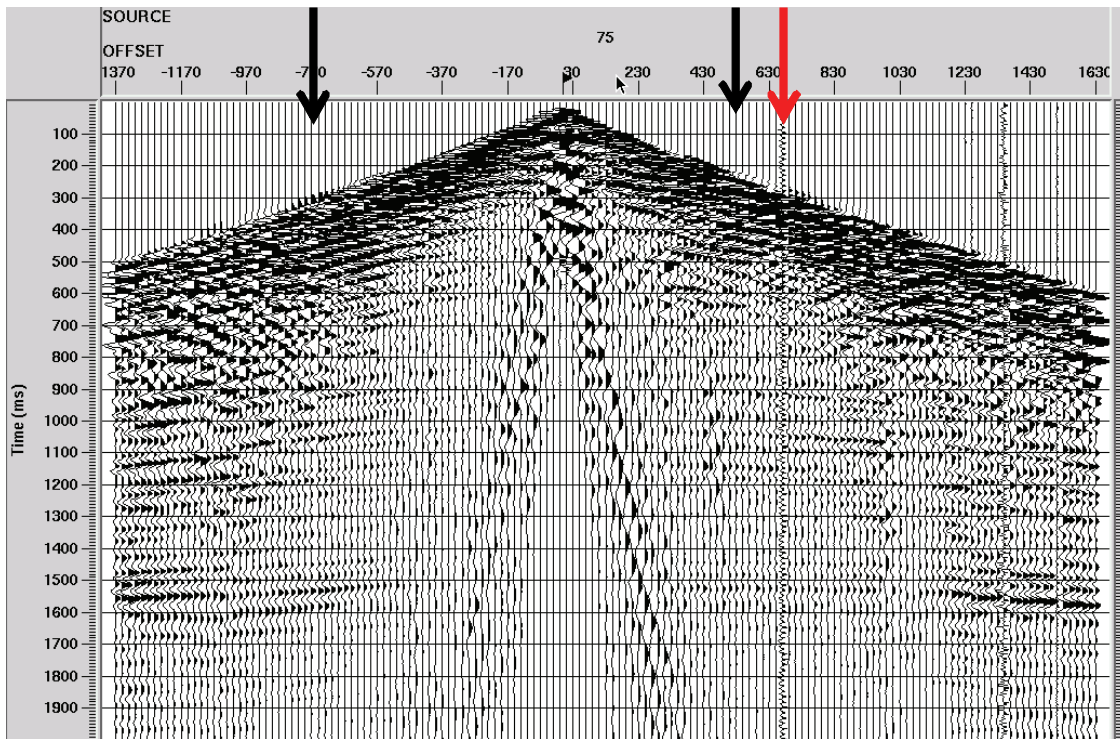


Burg wavelet spectrum estimate—A. 3 coefficients; B. 5 coefficients; C. 10 coefficients; D. 20 coefficients—no smoothing on any of these estimates

FIG. 7. Dependence of the Burg wavelet estimates on the number of Burg coefficients

Deconvolution design

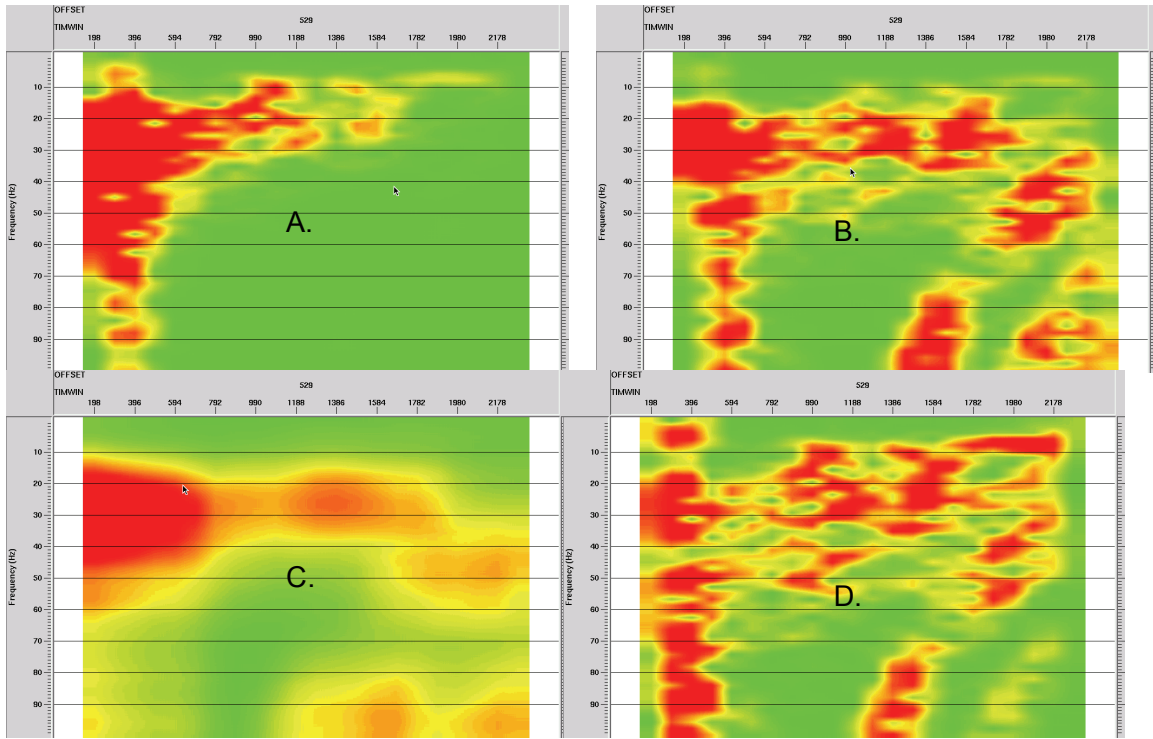
To illustrate the use of Gabor_sc diagnostic mode in designing deconvolution operations, we analyze two different traces from the well-known Blackfoot 2D survey. Figure 8 shows a specific shot gather from that survey, and we have flagged three traces on that gather with arrows. We will analyze two of these, in order to illustrate our diagnosis process.



Blackfoot shot 75 after radial trace filtering

FIG. 8. Typical Blackfoot shot gather—arrows designate specific traces. Red arrow indicates trace contaminated with 60 Hz.

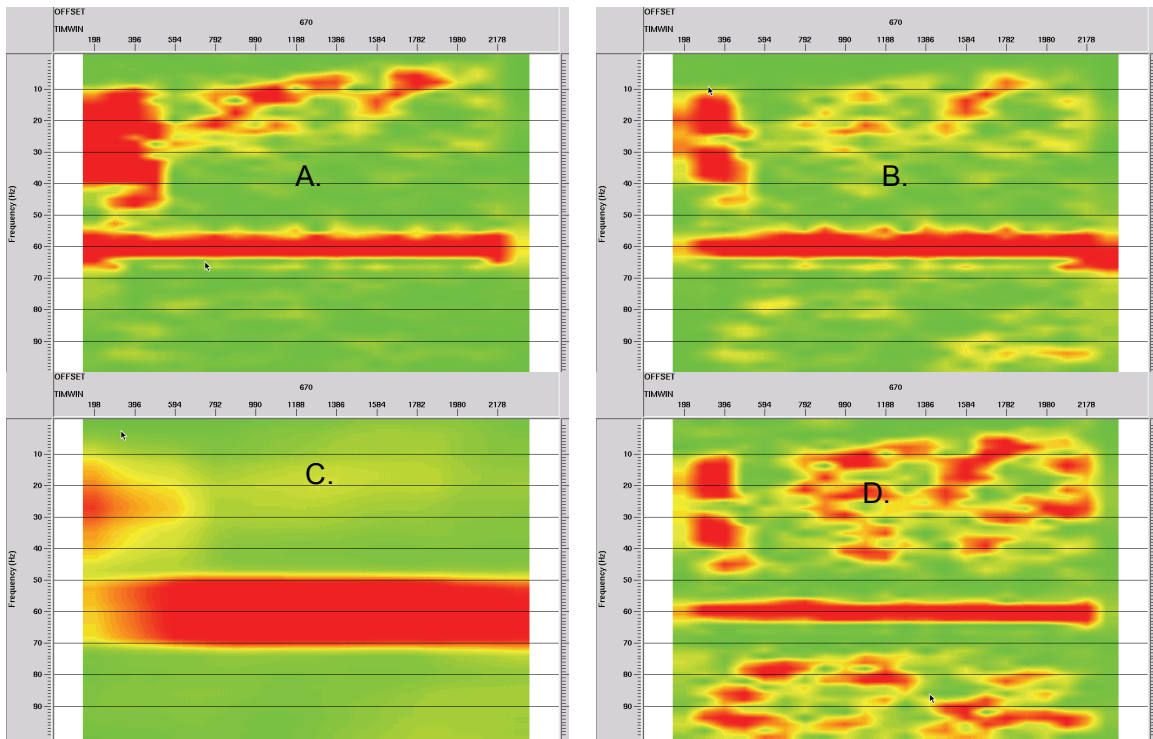
Since we have already displayed the spectra from the flagged trace at -770 m offset, we display the Gabor spectra of the trace at 529 m offset in Figure 9. We show, respectively, the raw spectrum, the residual spectrum (after hyperbolic smoothing), the smoothed wavelet estimate, and the spectrum of the deconvolved trace. The relationships of the four spectra are relatively intuitive and provide some feel for the effectiveness of the deconvolution operation.



Gabor magnitude spectra for trace at offset 529 m—A. raw spectrum; B. residual spectrum after removing Q-function; C. smoothed wavelet estimate; D. deconvolved trace spectrum

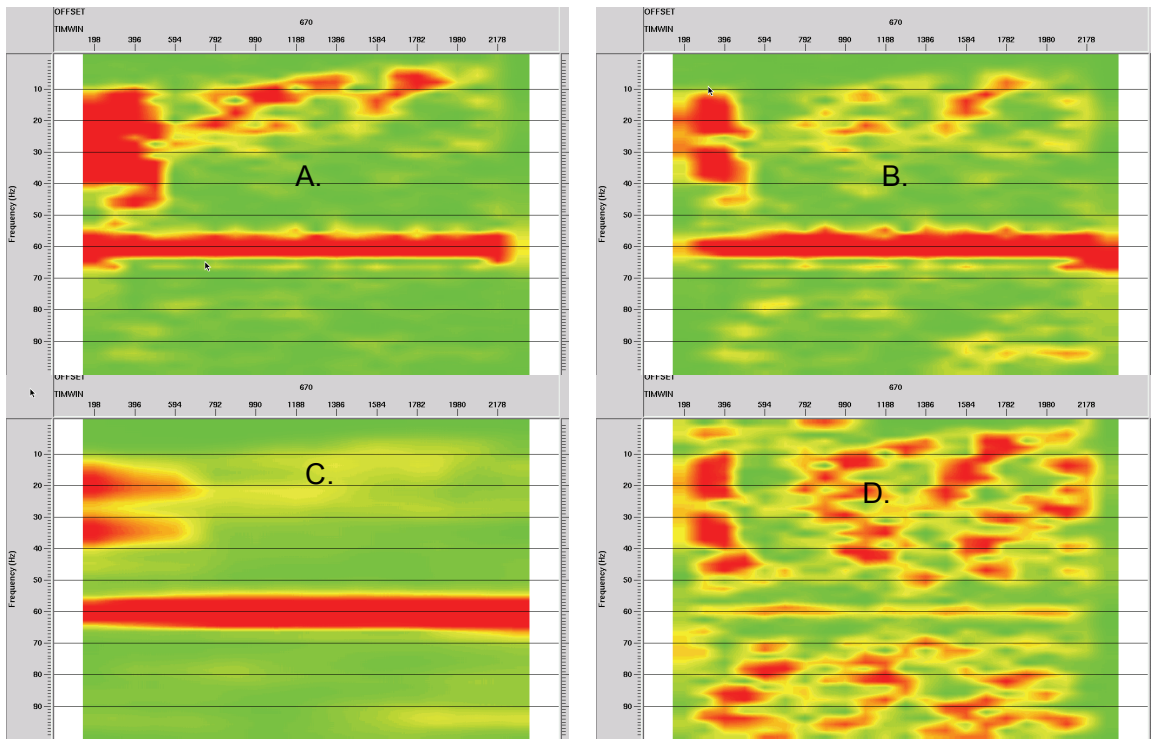
FIG. 9. Gabor spectra tracking the deconvolution of Blackfoot trace at offset 529 m

The trace at 670 m, as seen on the gather in Figure 8, is obviously contaminated by a high level of 60 Hz power pickup, and presents more of a problem for deconvolution. Figure 10 illustrates the four Gabor spectra corresponding to this trace and the first attempt at its deconvolution. The 60 Hz component is dominant in the raw spectrum, as well as in the residual spectrum; and the wavelet smoothing only serves to broaden the disturbance, as seen in the wavelet spectrum. Hence, there should be no surprise that the spectrum of the deconvolved trace, while showing some evidence of improvement in other spectral detail, is still dominated by the 60 Hz. Figure 11 shows how we can use the diagnostic plots in Figure 10 to make a better choice of deconvolution parameters. Since the frequency smoothing used to obtain the wavelet obviously smears the 60 Hz component, we can reduce this smoothing by choosing a shorter window. This has the effect of forcing the 60 Hz component, in its relatively unsmoothed form, to be a part of the wavelet estimate. The spectrum of the resulting deconvolution, in Figure 11, shows the obvious benefit of this...the 60 Hz component is greatly reduced, and the other spectral detail much enhanced.



Gabor magnitude spectra for Blackfoot trace at 670 m offset—A. raw spectrum; B. residual spectrum after removing Q-function; C. smoothed wavelet spectrum; D. spectrum of trace deconvolved with spectrum in C.

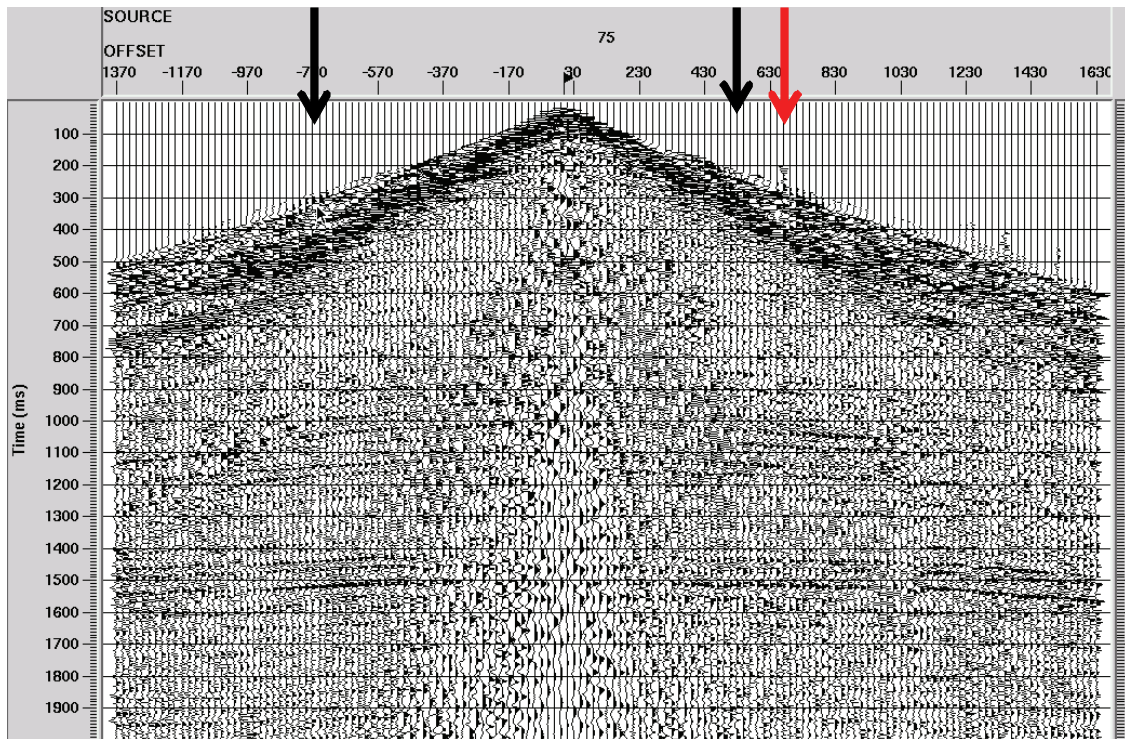
FIG. 10. Gabor spectra tracking the deconvolution of Blackfoot trace at offset 670 m. Note that the 60 Hz component persists into the deconvolved trace spectrum (D.)



Gabor magnitude spectra for Blackfoot trace at 670 m offset—A. raw spectrum; B. residual spectrum after removing Q-function; C. smoothed wavelet spectrum with less frequency smoothing; D. spectrum of trace deconvolved with spectrum in C.

FIG. 11. Gabor spectra tracking the deconvolution of Blackfoot trace at offset 670 m. Note that by decreasing the frequency smoothing of the wavelet estimate, the 60 Hz component is much more effectively removed from the trace as part of the deconvolution operation.

Figure 12 shows the Blackfoot shot from Figure 8 after being deconvolved with the parameters determined from the diagnostics above. It can be seen that all the traces are greatly whitened, and the decay of amplitude with time has been compensated, as well (one of the features of Gabor deconvolution). Interestingly, the trace originally contaminated with 60 Hz now appears to have at least some usable reflections.

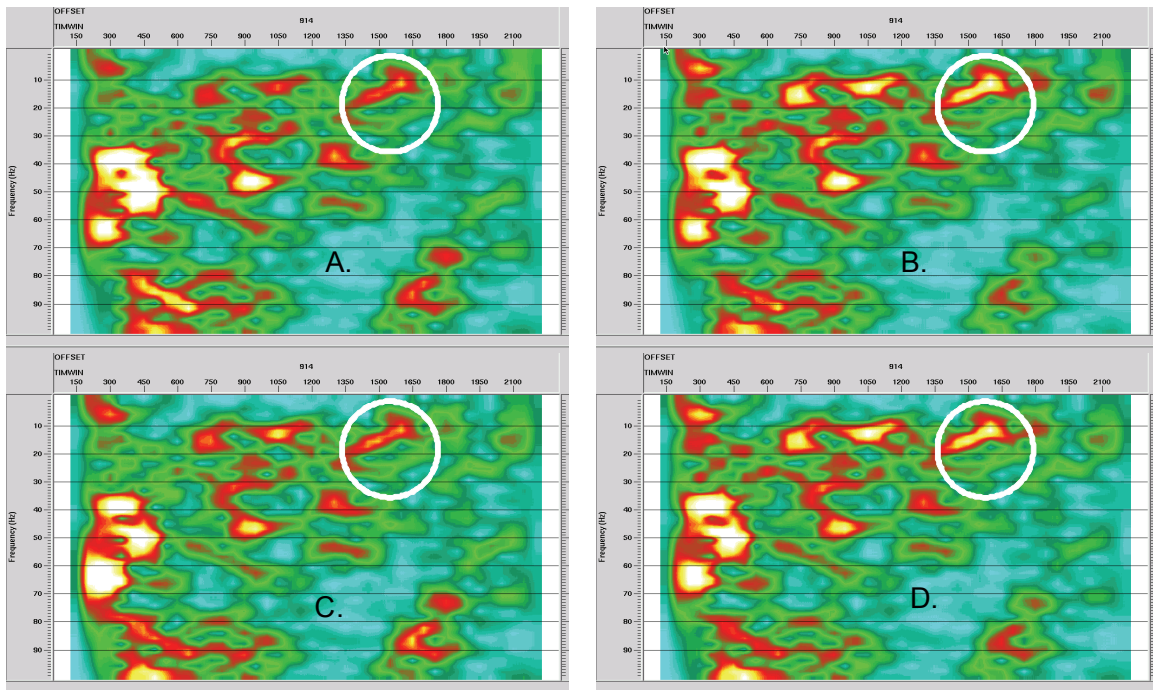


Blackfoot shot gather 75 after Gabor deconvolution

FIG. 12. Blackfoot shot gather after Gabor deconvolution, guided by diagnostics.

Gabor_sc algorithm modification

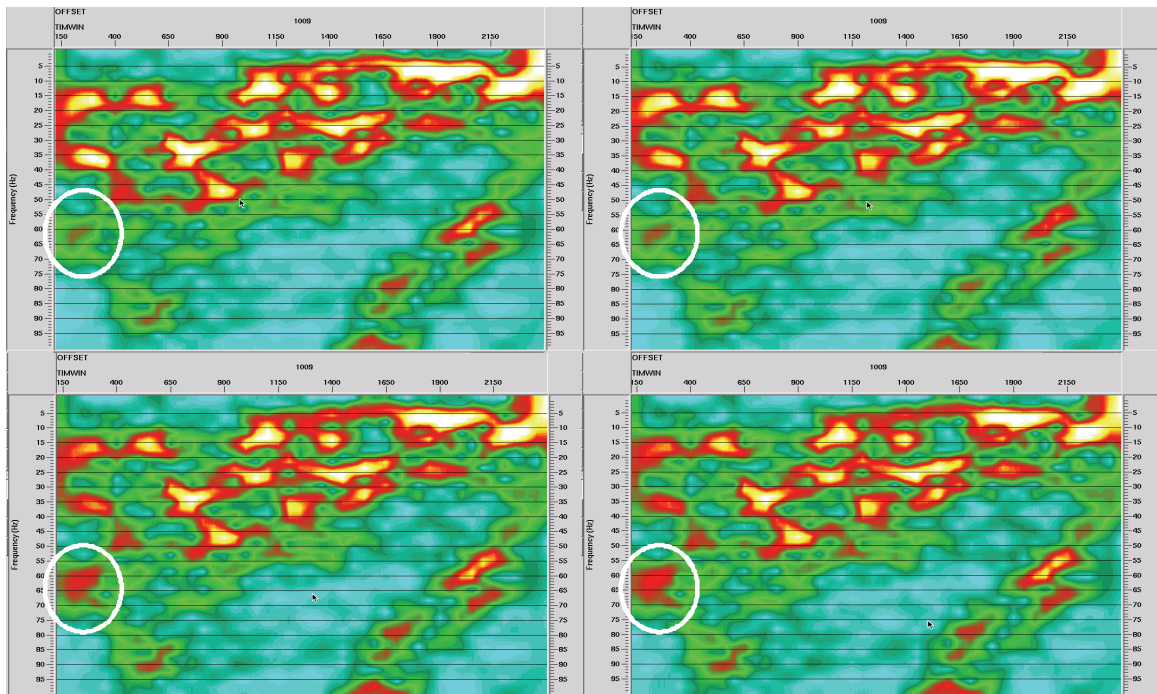
During the design of Gabor_sc as an iterative, surface-consistent deconvolution process, the additive update term of the Gabor spectra of the four deconvolution operator components was scaled by a parameter whose value was set arbitrarily. Early experience with the algorithm indicated that when the parameter value was too large, the iteration process was unstable; it oscillated between over-whitening and under-whitening during each iteration, rather than converging to a stable solution. After some trial and error, the scalar was set at a seemingly reasonable value. When we revisited the issue with the diagnostic mode of Gabor_sc, we were better able to see the behaviour of the algorithm. Figure 13 shows Gabor spectra of the first pass deconvolution of a trace from the Blackfoot survey as well as the first three iterations. When comparing the results for the four passes, it is apparent that each successive iteration tries to boost energy in regions of lower energy (whitening), but that the boost is too great, and the next iteration then tries to compensate, and this leads to oscillation.



Gabor spectra of deconvolved trace—A. 1st pass gabor_sc (quadratic factorization); B. 2nd pass gabor_sc (SIRT iteration); C. 3rd pass gabor_sc (SIRT iteration); D. 4th pass gabor_sc (SIRT iteration). Note the oscillation in spectral peak amplitudes within the circle, for example, progressing from A. to B., B. to C., C. to D.

FIG. 13. Gabor spectra showing the instability of an earlier version of gabor_sc in deconvolution mode. The relative amplitudes of the various spectral peaks oscillate between passes—some peaks grow higher from pass 1 to pass 2, then decrease from pass 2 to pass 3, then increase again from pass 3 to pass 4.

After decreasing the iterative coefficient we generated Figure 14, which shows the deconvolution of a different trace. In this case, the spectra for the consecutive iterations show a more systematic and monotonic improvement toward the desired white spectrum. The first pass estimate does most of the whitening, while the first iteration simply increases the whitening. The second iteration hardly changes the spectrum at all, indicating convergence of the iteration.

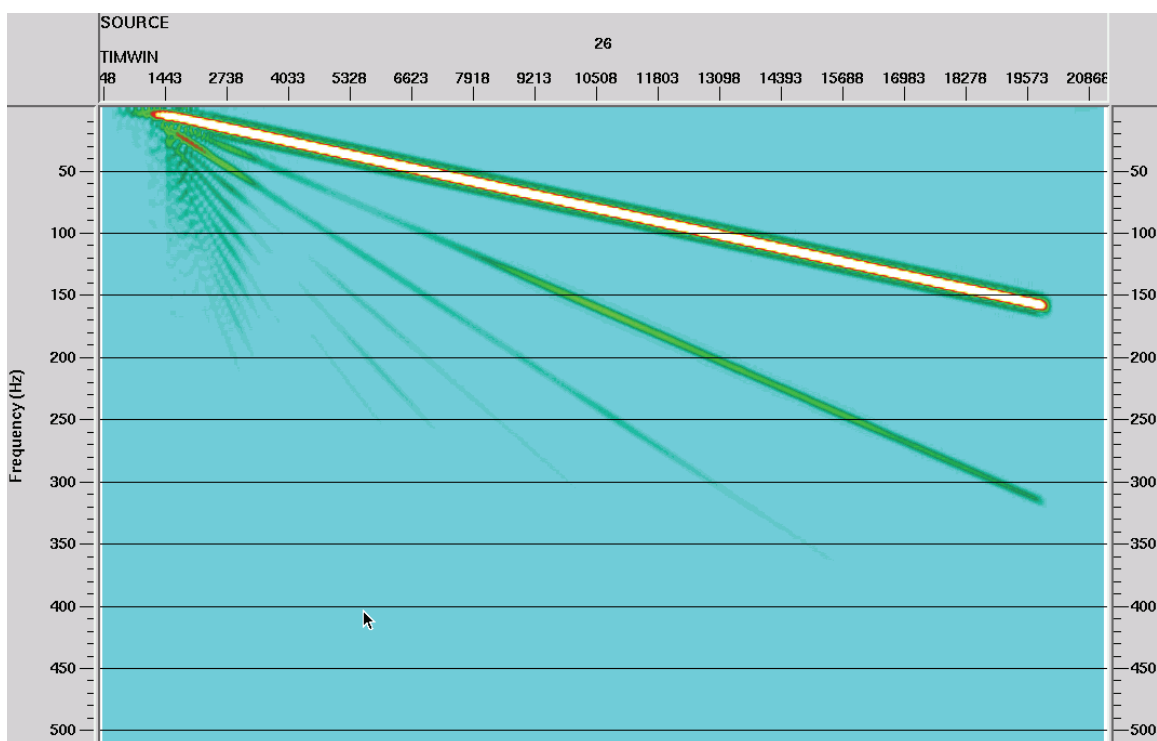


Gabor spectra of deconvolved trace—A. 1st pass gabor_sc (quadratic factorization); B. 2nd pass gabor_sc (SIRT iteration); C. 3rd pass gabor_sc (SIRT iteration); D. 4th pass gabor_sc (SIRT iteration). Note the smooth progression in relative spectral peak amplitudes within the circle, for example, progressing from A. to B., B. to C., C. to D.

FIG. 14. Gabor spectra illustrating the stability of the latest version of gabor_sc with a diminished iteration coefficient. The relative amplitudes of spectral change smoothly from pass 1 to pass 2, then from pass 2 to pass 3, and from pass 3 to pass 4.

FT plot of Vibroseis sweep

When designing field surveys, it is useful to be able to analyse in detail the signal output by the source, particularly a controlled source like Vibroseis. Our diagnostic mode of Gabor_sc can be useful for generating a frequency-time plot of the outgoing signal to assist in parameter adjustment. Figure 15 is an example of such a plot. Note that such a plot easily shows the various harmonics, as well, including their relative strength with respect to the fundamentals in the signal.



File 362, sweep 26, scalar 100 TIMWIN is the centre of the 300 ms Gabor analysis window

FIG. 15. Gabor spectrum of a vibroseis sweep, used as a diagnostic for sweep design.

DISCUSSION

The diagnostic mode of Gabor_sc has already proven itself to be of significant value in assisting with parameter choice for deconvolution, verification of algorithm performance, and providing diagnostic FT plots for various purposes. It can be included anywhere in a processing flow to provide FT analysis of the seismic traces passing a given point in the flow. Future studies to be done might include experimenting with various window shapes (varying the exponent for the Lamoureux Window, for example).

ACKNOWLEDGEMENTS

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APPENDIX

We have included here the documentation for the modified Gabor_sc.

Gabor surf consistent

This module applies Gabor Deconvolution in a surface-consistent manner to a panel of seismic traces, trace-by-trace. Gabor deconvolution is a time-varying deconvolution whose operator adapts to the characteristics of the particular data captured by a time-overlapped set of windows. Gabor surface consistent differs from its predecessors in that the decon operator derived from the first pass of a trace is split into an offset wavelet component, source wavelet component, receiver wavelet component, and Q-factor component. These components are stored according to their offset, source, receiver, and midpoint header values, respectively. Subsequent trace decon operators are summed into these offset, source, receiver, and midpoint arrays, also according to their associated trace header values. After all the traces in a line are read, the program begins a second pass through the trace file. During the second pass, averaged decon operator components are retrieved from the respective arrays according to matching trace headers, combined into a single decon operator for each trace, the phase computed (either zero or minimum phase) and the composite decon operator applied to the trace. Currently, the composite wavelet is the product of offset, source and receiver wavelets, divided by the Q-factor.

An experimental extension of the routine uses the second, and subsequent passes through the data set to iterate the estimated offset, source and receiver wavelet arrays by dividing products of pairs of the previous estimates for offset, source and receiver into the composite wavelet estimate from the current pass to obtain new estimates for offset, source and receiver wavelets. These estimates are summed into new offset, source and receiver wavelet arrays and accumulated for the whole line. Third and subsequent passes through the data retrieve the iterated offset, source and receiver wavelets for each trace, as well as the non-iterated Q-array and builds a composite deconvolution operator for each trace. In the current release, traces are output after the second pass and all subsequent passes, thus providing increasingly iterated versions of the surface-consistent deconvolved traces.

This experimental version of surface-consistent Gabor decon is experimenting with offset-dependence, placing it on a par with source and receiver dependence. As our ideas evolve, we may decide to fold it into the Q-factor instead. Currently, the "wavelet" magnitudes extracted from the input Gabor transform after hyperbolic smoothing are summed into arrays indexed by source surface position, receiver surface position, and source-receiver position difference (equivalent to absolute offset). This means that as ideas for incorporating offset-dependence are available, the offset-summed wavelet estimate will be immediately available for incorporation into the spectral arithmetic within the decon operator computation.

Updates

This version of Gabor surface consistent is the first and has not been thoroughly tested.

A diagnostic mode has been added to the surface-consistent Gabor deconvolution module. In this mode, only diagnostic traces are output, no actual

deconvolution is performed. Four kinds of diagnostics, all Gabor magnitude spectra, can be requested: 1)Raw Gabor spectra of input traces; 2)The residual raw Gabor spectra (after dividing out the Q-function); 3)The Q-function derived during hyperbolic smoothing; and 4)The smoothed residual Gabor spectra used to estimate the wavelet.

Theory

Gabor deconvolution is based on the Gabor Transform, which is a way to analyse a seismic trace for time-varying spectral characteristics. Because this transform explicitly captures the non-stationary behaviour of a seismic trace, it constitutes a natural basis for its deconvolution. The deconvolution is applied in the frequency domain by performing a complex division of the Gabor Transform by the derived deconvolution operator. The time-dependency of the resulting array is removed by summing over the time-gate dimension of the array.

Surface-consistency is invoked for deconvolution anytime it is considered that the "wavelet" derived for each trace has particular features attributable to either the source location or receiver location, or both. Surface consistent arithmetic thus leads to more robust estimates for the parts of the deconvolution wavelet peculiar to its endpoints

Usage

This version of Gabor deconvolution is intended for application to pre-stack data, since it specifically requires certain trace headers for its proper functioning. The input data may be source gathers, receiver gathers, or CDP gathers.

The program must estimate memory requirements in the initialization phase and thus requires the existence of a database for any line submitted, from which it finds the total number of offsets, shots, receivers, and CDPs. Any line for which there is no pre-existing database must have one created using the 'Extract database files' function following the 'Disk data input'.

In order for the program to function properly, the 'Disk data input' which precedes it must have the "Read data multiple times" option set to "yes", and the number of iterations immediately below it set to 2 or more. If the data set is read twice, the output from the program will be the input traces deconvolved with the first pass estimated source and receiver wavelets. If the data set is read three or more times, the output will consist of the input traces first deconvolved with the source and receiver wavelets from the first pass, then the same input traces deconvolved with the source and receiver wavelets estimated by iteration. The complete data sets are distinguished from one another by the trace header 'DISKITER', which is set to '2' for the traces deconvolved by the first wavelet estimates and '3', (or more) for the traces deconvolved by the iterated wavelet estimates. This trace header thus allows several output data sets to be written as separate files, using, for example, an 'IF'--'ENDIF' loop to test the value of 'DISKITER'.

In diagnostic mode, the program reads input data gathers only once, so the "Read data multiple times" option in 'Disk data input' must be set to "no". In diagnostic mode, for every trace ensemble read, one diagnostic ensemble is output, with the following characteristics: Each input trace generates a complete Gabor spectrum, which consists of one magnitude spectrum for each of the analysis windows specified by the parameters. This means that for N overlapping analysis windows, N output traces will be generated for each input trace. Hence, the output ensemble has N times as many traces as the input gather. Although the output traces have as many samples as the input traces, only samples up to the Nyquist frequency are non-zero,

so the output traces should be truncated externally, before writing to disk, to limit file size.

Since each input trace generates N diagnostic traces, a new trace header, TIMWIN, is introduced to help distinguish those traces--the time in ms associated with the centre of the analysis window associated with that trace. This header can be used to help sort the Gabor spectra externally for other types of display--for example, a display of local spectral changes in a single Gabor analysis window as a function of source position, and so forth. Any kind of trace ensemble can be input to Gabor_sc, so diagnostics can be generated as a function of source, receiver, midpoint, and offset, just by sorting the input data set externally before input. Of the four diagnostics available, displays of the Q-function can help determine the proper corridor width for hyperbolic smoothing; while displays of the raw input trace residuals compared to the displays of smoothed residuals can help determine the proper smoothing parameters, in both frequency and time, for wavelet estimates.

One useful way in which to utilize the diagnostic mode of this program is to place it immediately behind a previous run of Gabor deconvolution, (either Gabor2 or Gabor_sc) in order to evaluate the effectiveness of the deconvolution. In this application, looking at the Gabor magnitude spectra of the raw input traces (actually the output from the previous decon) can help analyze the effectiveness of the decon parameters.

In diagnostic mode, any or all of the smoothing parameters in gabor_sc can be set to zero to assist in data analysis (Corridor width for hyperbolic smoothing, Wavelet smoothing window width (Hz), and Wavelet smoothing window length (sec)).

Half-width of the analysis/synthesis window

This is the half-width in seconds of the Lamoureux window functions used for analysis and synthesis of the data traces. Since the Lamoureux functions have a finite width between their zero amplitude points, the half-width is half the distance between the zero amplitude points, not the 1/e amplitude points as in Gaussian functions. A reasonable value is between 0.1 and 0.3 seconds.

Window increment factor

Lamoureux windows are properly overlapped and normalised if the start point (zero amplitude) of one window coincides with the centre of the preceding window, and the end point (also zero amplitude) coincides with the centre of the succeeding window. In order to keep this proper window normalisation, the increment between windows may be decreased only by applying additional properly overlapped sets of windows, offset from the original windows by increments evenly divisible into the original window width. Hence an increment factor of 2 generates an additional overlapped set of windows, offset from the original set by one fourth of the window width; an increment factor of 3 generates two additional overlapped sets of windows, the second and third offset from the first by 1/6 and 1/3 of the window width, respectively, and so forth. Proper normalisation is maintained by dividing the windowed data by the window increment factor, which is equal to the total number of unity-normalised sets of overlapped windows used to sample the data. Using a value greater than one appears to stabilise the result, particularly on noisy data.

Factor to extend window before FFT

This factor is applied to the window length to determine the actual length of the FFT used to analyze the windowed trace segment. The

trace segment is extended by this factor, then further extended to the next largest power of two prior to the FFT. Default this unless you know what you're doing.

Pad input traces before windowing

This is a switch parameter which determines whether or not the input traces are padded before windowing, to diminish end effects. If this switch is set to true, the following parameter is used to determine the length of pad to be added to both beginning and end of the traces. The pad values are random noise whose level is set to -300 dB of the rms amplitude level of the current trace, in order that windows never encounter an all-zero trace segment. Default this value unless you know what you're doing.

Fraction of window width for trace padding

If the switch above is set to true, this parameter is used to determine the number of pad values to append to either end of the trace. The recommended value is more than half a window width, to move end effects off the visible seismic trace. Default this value unless you know what you're doing.

Slope exponent for Lamoureux window function

This integer is used as an exponent in the computation of the values of the Lamoureux window. Its default value of 2 is a safe choice. Larger values can lead to window artefacts under conditions of high noise, low signal level, and small window overlap.

Application exponent for analysis window

Prior to being applied to the input trace, the values of the analysis window function are raised to this power (actually a root, since the value must be ≤ 1.0). The values of the synthesis window function are then raised to the complementary power (1.0 minus application exponent). A value of 0.5 applies a square root window to both analysis and synthesis; one applies a full strength analysis window and no synthesis window; zero applies no analysis window function and a full strength synthesis window. The default value here is safest.

Choose type of spectrum for wavelet estimate

This parameter chooses whether the Fourier Transform or the Burg algorithm is used to compute the spectral magnitudes used to construct the deconvolution operator. The Burg algorithm is somewhat slower than the FFT, if used with many coefficients. This type of spectral analysis is best suited to source wavelets with known prominent frequency peaks.

Number of coefficients for Burg spectrum

This parameter only appears if Burg spectra are used in the decon operator. In general, the more coefficients, the more detail the Burg spectrum contains. Since the spectra are smoothed to obtain the decon operator, a small number of coefficients (3-5) will often be more effective than a larger number (10) and will run somewhat faster as well. Using a small coefficient number is similar to applying more smoothing, so the spectral smoothing parameters below can be smaller in this case.

Choose minimum or zero phase deconvolution

While a minimum phase deconvolution would be the norm here, zero phase can be chosen, and it takes less time to construct the operator.

Choose corridor width of hyperbolic smoothing in Hz-sec

This parameter determines how much smoothing occurs in the constant time-frequency method. A wide corridor applies more smoothing, forcing more of the time-dependency into the subsequent wavelet estimation. A value of 10 to 30 Hz-sec is reasonable for many data.

Wavelet smoothing window width in Hz

Determines the number of spectral magnitude points to be smoothed in frequency. A value of 10 Hz is a reasonable starting point. A smaller value will help deconvolve monofrequency noise components (like 60 Hz)

Wavelet smoothing window length in seconds

Determines the number of spectral magnitude points to be smoothed in time. A reasonable value is one to two times the window half-width (first parameter).

Begin time in seconds for Q estimation

This parameter determines the time before which estimated Q factor is not computed.

End time in seconds for Q estimation

This parameter determines the time after which estimated Q factor is not computed.

Stability factor for spectral division operations

This parameter determines the fraction of the maximum spectral magnitude to be added to all deconvolution operator spectral magnitudes to prevent any division by zero. The default value is a safe option.

Diagnostic switch

This parameter, normally zero, is the switch that enables diagnostic output from the input data, rather than deconvolution. Setting the parameter to one invokes the diagnostic mode and enables the following parameter.

Diagnostic descriptor

This parameter is displayed only if "Diagnostic switch", above, is set to one. There are four possible values: 1 means output the raw Gabor magnitude spectra for the current trace; 2 means output the residual Gabor magnitude spectra after dividing out the Q-function and smoothing; 3 means output the Q-function for the current trace; and 4 means output the residual raw Gabor magnitude spectra after dividing out the Q-function.

References

G. Margrave, M. Lamoureaux, D. Henley, C. Montana