Z-99 Footprint Suppression with Wavenumber Notch Filtering for Various Acquisition Geometries

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Abstract

It has been shown previously that 3D acquisition footprint can be attenuated either on time slices or on frequency slices by applying a wavenumber notch filter. We have recently experimented with wavenumber domain notch filtering on frequency slices on some commonly used data acquisition geometries from the Middle East and found out that this method can be used with all the geometries we have tested and with data of various geologic complexity.

Introduction

The first published observation known to us of acquisition footprint problems on 3D volumes and a deterministic solution for it is by Meunier et al (1992). Later Gulunay et al (1994,2000) suggested a data adaptive wavenumber notch filtering method on frequency slices. Drummond et al (2000) suggested the use of wavenumber domain deterministic notch filtering but on time slices instead. Because their method was not data adaptive in filter derivation and noise patterns vary with time they suggested the use of adaptive subtraction of noise. Geometry driven deterministic time slice filtering of 3D data for footprint attenuation was later proposed by Soubaras (2002). Karagul et al (2004) showed interesting results on a data set with complex structures using Soubaras method. Most recently, Al-Bannagi et al (2004) proposed time slice SVD filtering where footprint attenuation and random noise attenuation are done in one step by selecting certain singular values.

Seeing such prior publications one might naturally wonder what the pros and cons of working in time or frequency slices are as they are not necessarily the same even when all the frequencies are filtered in a frequency domain method. One might also wonder if data adaptive methods like the ones by Gulunay (2000) can handle complex field patterns or should we design deterministic filters for each of such study. Leaving the first question to future studies we have developed a frequency slice wavenumber notch filtering method, called FKF3D, similar to the one published by Gulunay and have tested it on various data sets from the Middle East. This paper reports some of the results from that study.

Geometry of the Surveys and The Footprint

We have experimented with many geometries among which were “Single zig-zag”, “Double Zig-zag” “Triple Zig-zag”, “Shifted double Zig-zag” and “Checker-Board”. Here we will present the results from two of such surveys. Figure 1 shows source receiver configurations (on the left) for a layout known as Double Zig-Zag geometry. On the right side of that figure the k_x-k_y spectrum generated by FKF3D (on a shallow time zone, 0-400ms, in the first space window of size 100 lines and 100 crosslines) is shown. This plot represents the accumulated k_x-k_y spectrum found from data on all frequency slices. The red color is the peak (0 dB value), yellow is about -30 dB, and blue is about -60 dB. Spatial periodicity that exists in the surface layout translates to spectral peaks in the k_x-k_y domain in this fashion (x=crossline, y=line).

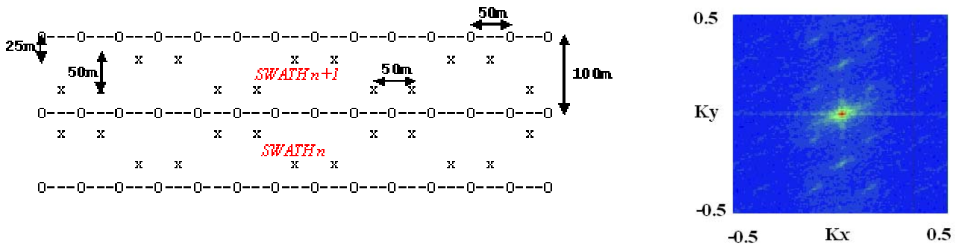

Figure 1: Double Zig-Zag field configuration (x=shot, o=receiver) and Kx-Ky spectrum estimated by FKF3D for a shallow time-space window.

Figure 2a shows the local maxima detected by FKF3D. Figure 2b is the filter to be applied to data in that time window. Note that red is 0 dB and gray is –36dB. Figure 2c shows the average k_x-k_y spectra after the filter is applied to data on the frequency slices. The peaks are suppressed well while the data point (k_x=k_y=0) is well preserved.

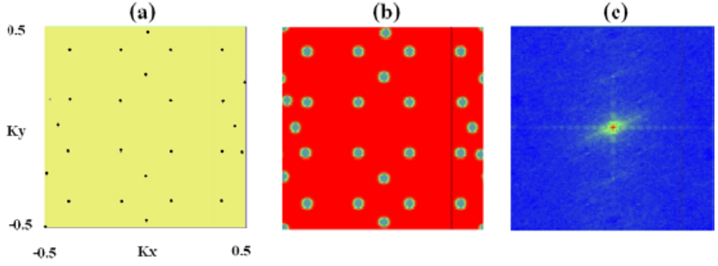

Figure 2: FKF3D QC plots; local maxima (left), filter (middle), output (right).

Figure 3 (left) shows input, output and difference sections on one of the lines in this survey as well as corresponding sections from a crossline (on the right). It is clear that FKF3D preserved the structured data while suppressing the footprint that existed in the shallow time windows. Figure 4 shows the time slice at 200ms. The footprint shows clearly on the upper left corner of that section. Figure 5 is the zoom of that corner.

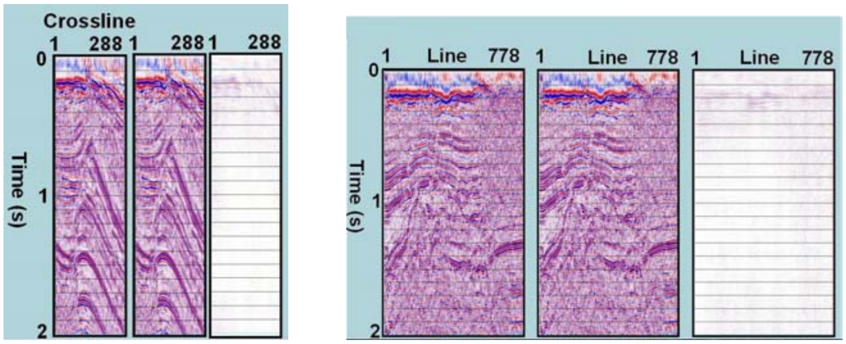

Figure 3: Input, output, and difference sections for a line (left) and a crossline (right).

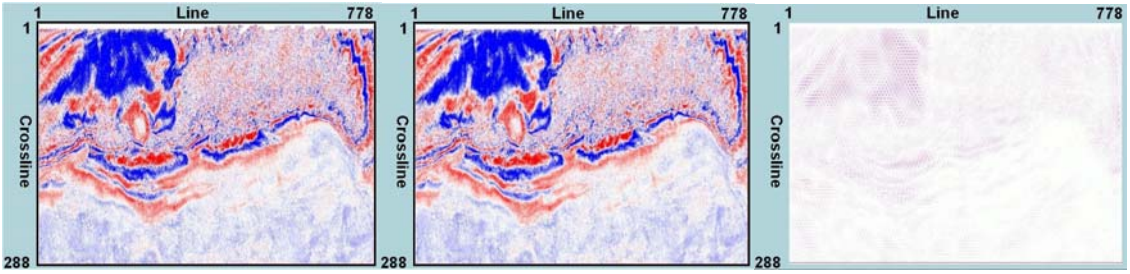

Figure 4: Time slice at 200ms. Input (left), output (middle) and difference (right) sections.

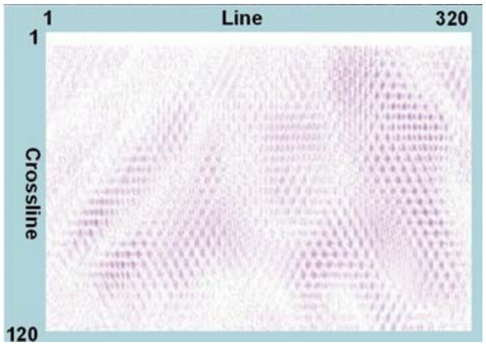

Figure 5: Zoom of the difference time slice in Figure 4.

Figure 6 shows another survey from the Middle East known as Shifted Double Zig-Zag. Again, we see spatial periodicity clearly forming as spectral peaks in the k_x-k_y domain of the shallow (0-400ms) time-space window.

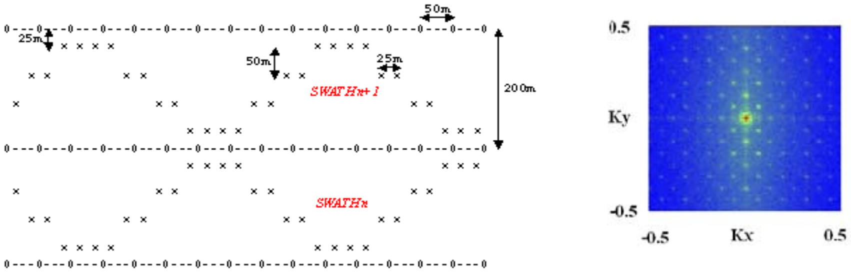

Figure 6: Shifted Double Zig-Zag field configuration (x=shot, o=receiver) and Kx-Ky spectrum estimated by FKF3D for a shallow time-space window.

Figure 7a, 7b, and 7c show, respectively, the local maxima detected by FKF3D, the filter, and the k_x-k_y spectra after the application of the filter to this time-space window.

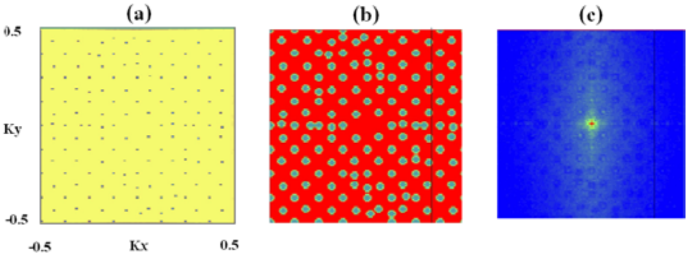

Figure 7: FKF3D QC plots; local maxima (left), filter (middle), output (right) on shifted double Zig-Zag.

On Figure 8 we see the input (left), output (middle) and difference (right) sections for the time slice at 400ms. Corresponding sections of a line and crossline are given in Figures 9 and 10.

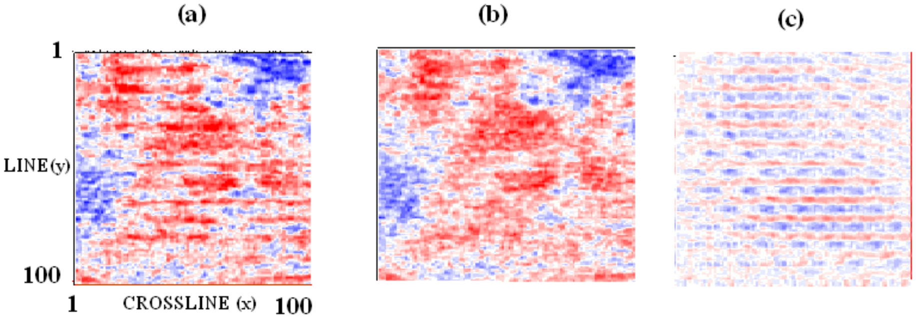

Figure 8: Time slice at 400ms. Input (left), output (middle) and difference (right) sections.

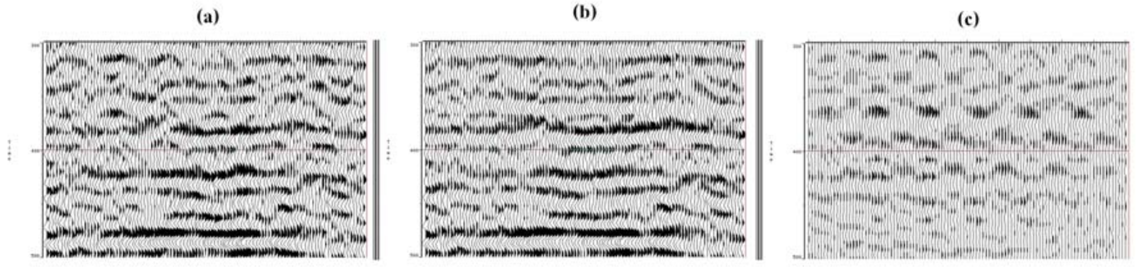

Figure 9: Input (left), output (middle), difference (right) sections for an inline.

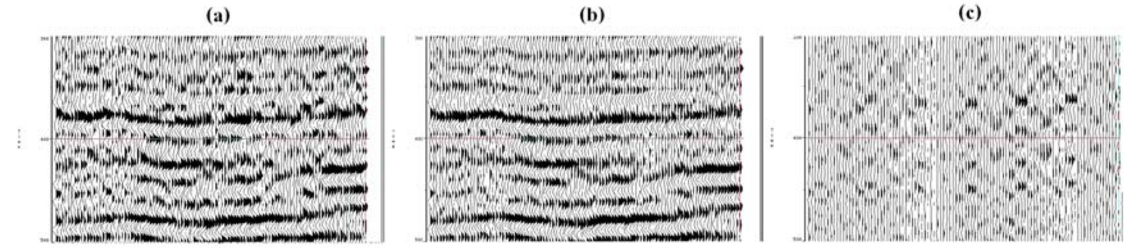

Figure 10: Input (left), output (middle), difference (right) sections for a crossline.

Conclusions

We observed in this study that 3D acquisition footprints can be effectively attenuated on many different acquisition geometries on data with moderate to complex geology without causing harm to underlying data using wavenumber domain notch filters on frequency slices.

Acknowledgments

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