Footprint Suppression on Megamerge Surveys

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Summary

Acquisition footprint manifests itself on 3D seismic data as a repetitive pattern of noise, anomalously high amplitudes, or structural shifts on time or horizon slices that is correlated to the location of the sources and receivers on the earth's surface. While accurate time-structure maps can be constructed from footprint-contaminated data, the effect of footprint on subsequent attributes such as coherence, curvature, spectral components, and P-wave impedance will be exacerbated.
In this work, we propose a workflow that uses a 2D Continuous Wavelet Transform (CWT) to suppress coherent and incoherent noise on poststack seismic data. The method involves decomposing time slices of amplitude and attribute data into voices and magnitudes using 2D wavelets. We exploit the increased seismic attribute sensitivity to the acquisition footprint to design a mask to suppress the footprint on the original amplitude data. The workflow is easy to apply and improves both the interpretability of the data and improves subsequent attribute resolution.

Theory

Fourier Transform

$$\hat{f}(k_x) = \int_{-\infty}^{\infty} f(x) e^{-ik_x x} dx, \tag{1}$$

1D Continuous Wavelet Transform

$$\mathcal{F}(a,u) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} f(x)\psi\left(\frac{x-u}{a}\right) dx, \tag{2}$$

$$\mathcal{F}(a,u) = FT^{-1}\left\{a\hat{f}(k_x)\widehat{\psi}(ak_x)\right\} \tag{3}$$

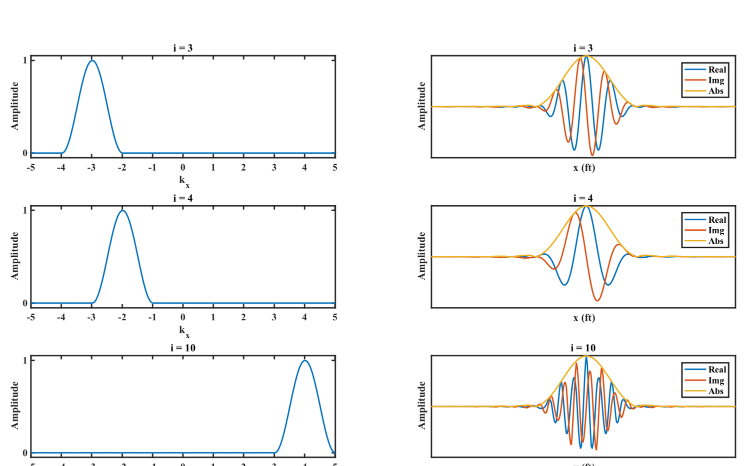

Figure 1: Figure1. Left, the spectrum of the wavelet in the wavenumber domain. Right: the wavelet in the space domain. We display the real, imaginary and absoulte of the wavelet.

2D Continuous Wavelet Transform

$$\mathcal{F}(i,j,x,y) = FT^{-1}\left\{ij\hat{f}(k_x,k_y)\widehat{\psi}(ik_x + jk_y)\right\} \tag{4}$$

Magnitudes and Voices:

$$mag(i,j) = |\mathcal{F}(i,j,x,y)| \tag{5}$$

$$voc(i,j) = \mathbb{R}\left[\mathcal{F}(i,j,x,y)\right] \tag{6}$$

Mask:

$$m(i,j)) = \left(\frac{mag(i,j)}{\epsilon mag(0,0) + mag(i,j)}\right) \tag{7}$$

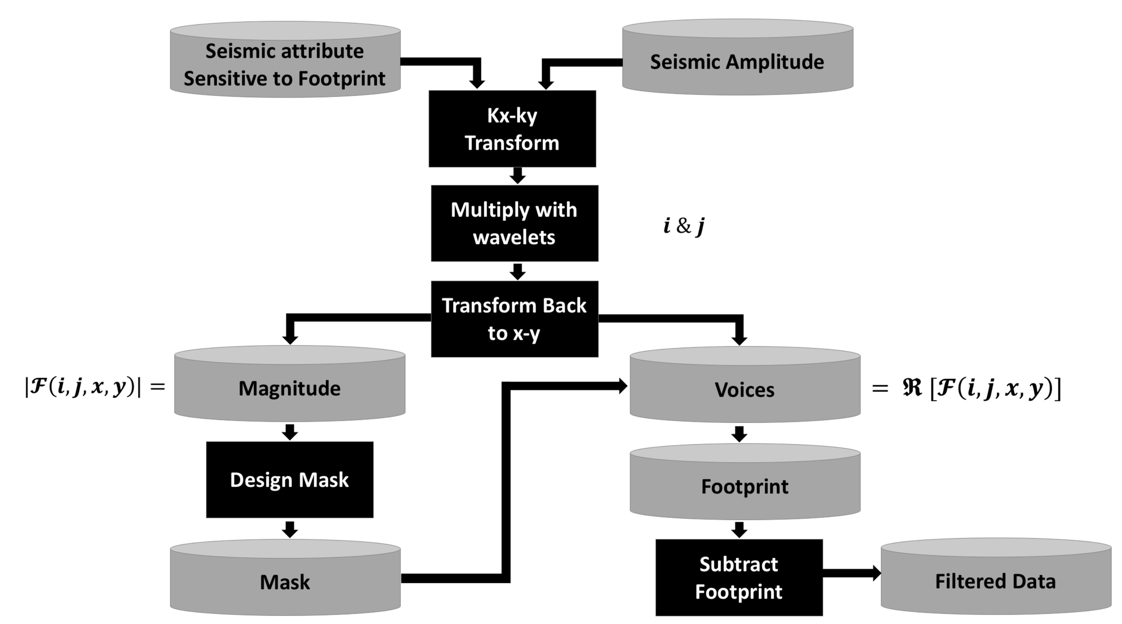

Figure 2: Coherence slice decomposed into different Magnitudes for different $k_x k_y$ components with diagonal, vertical and horizontal trends.

Results and Disscussion

We demonstrate the efficiency of the method on a horizon slice from a megamerge survey acquired in north central Texas. This data consists of four separate surveys all shot two decades ago, three of which had east —west receiver lines and one with north —south receiver lines. The horizon considered in this example is the PaloPinto, a shallow target at (t=0.9 s) with a pronounced normal fault (Figure 2). The coherence horizon is shown in Figure 4, the footprint masks the subtle faults making interpreting this time structure very challenging. Figure 6 shows the same horizon extracted after applying the workflow.

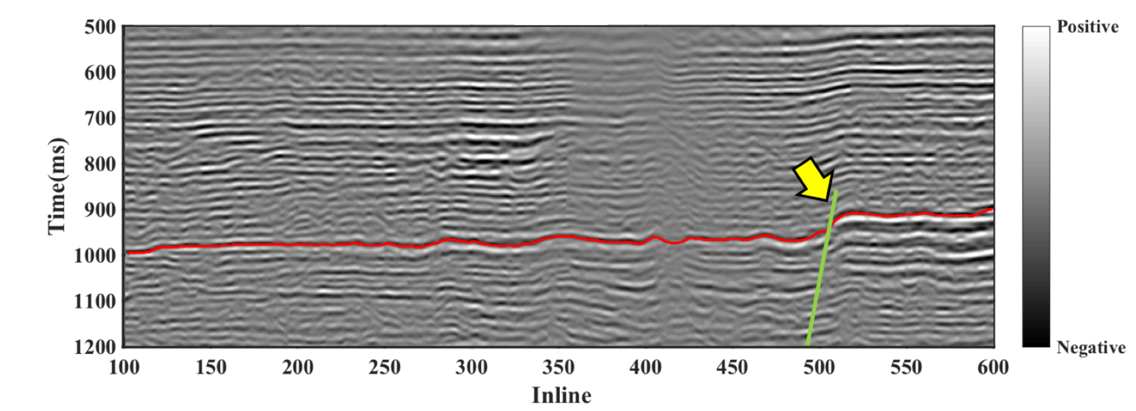

Figure 3: Crossline 1090 through the north Texas seismic data with PaloPinto horizon picked on the data. The yellow arrow indicates the fault that cuts through the horizon.

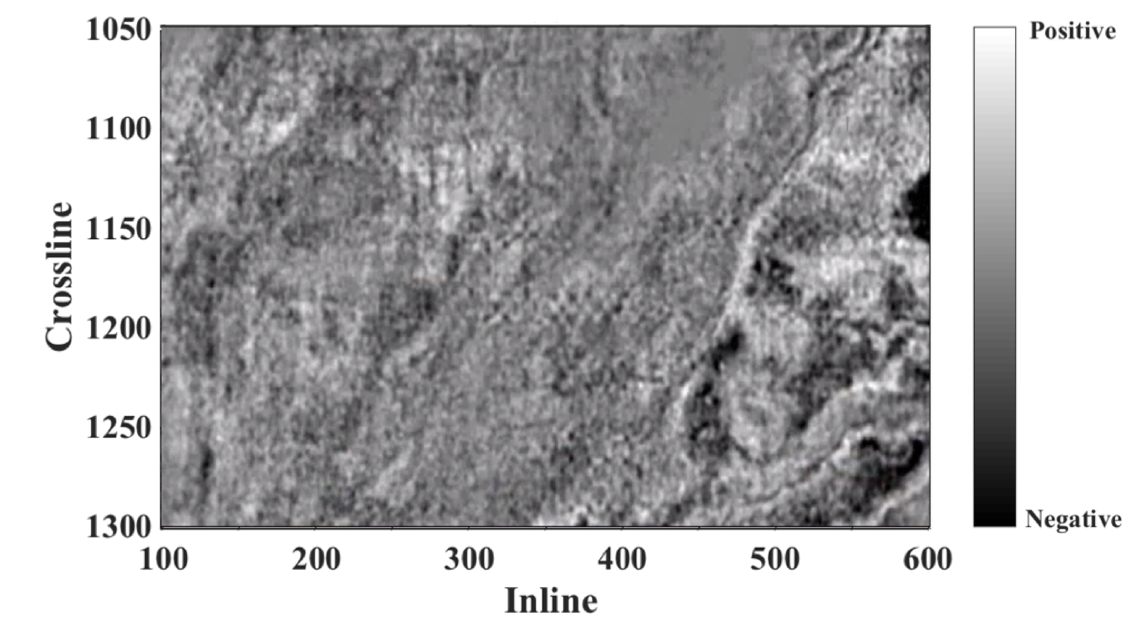

Figure 4: A horizon slice along the top PaloPinto through amplitude volume.

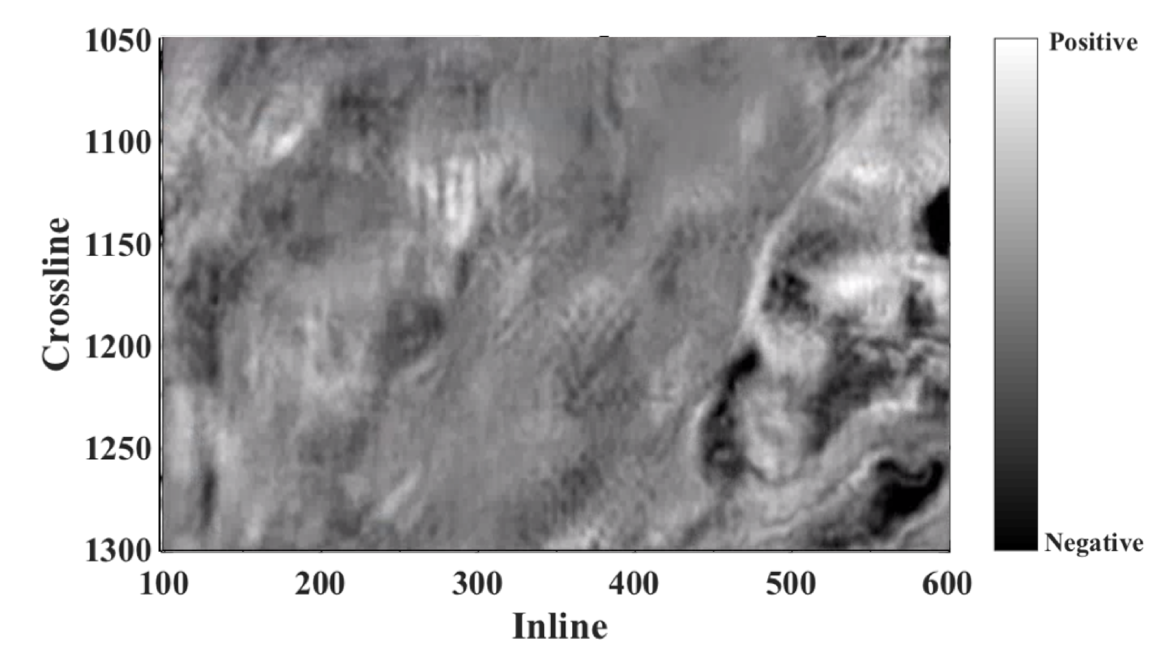

Figure 5: A horizon slice along the top PaloPinto through amplitude volume after filtering.

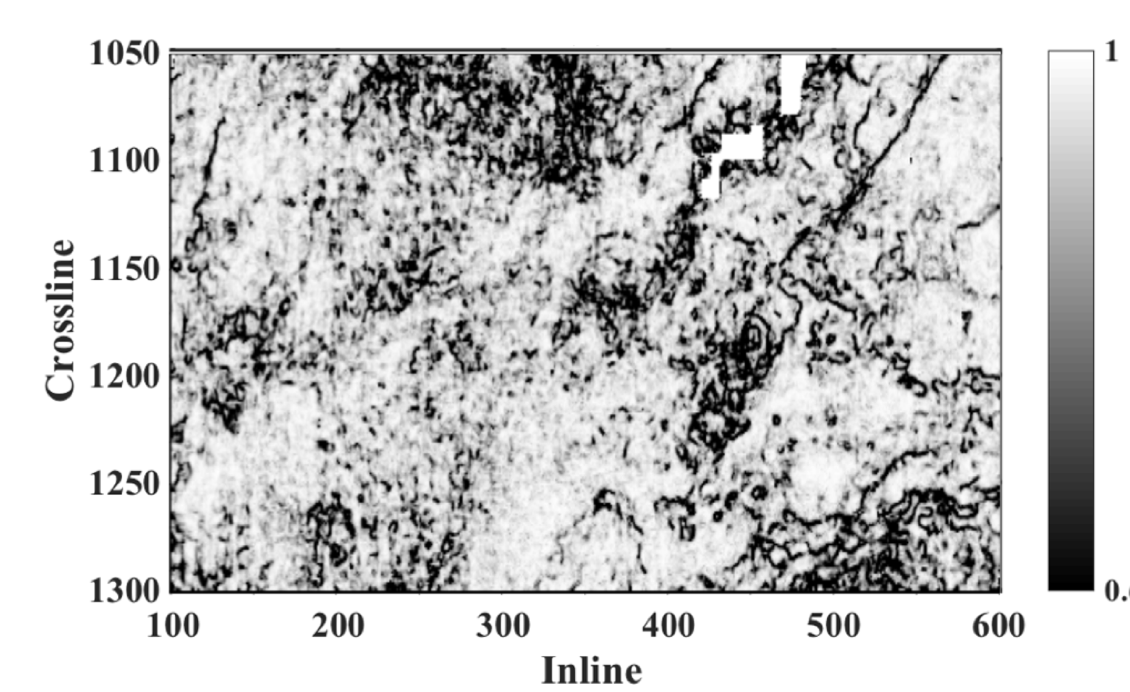

Figure 6: A horizon slice along the top PaloPinto through coherence volume.

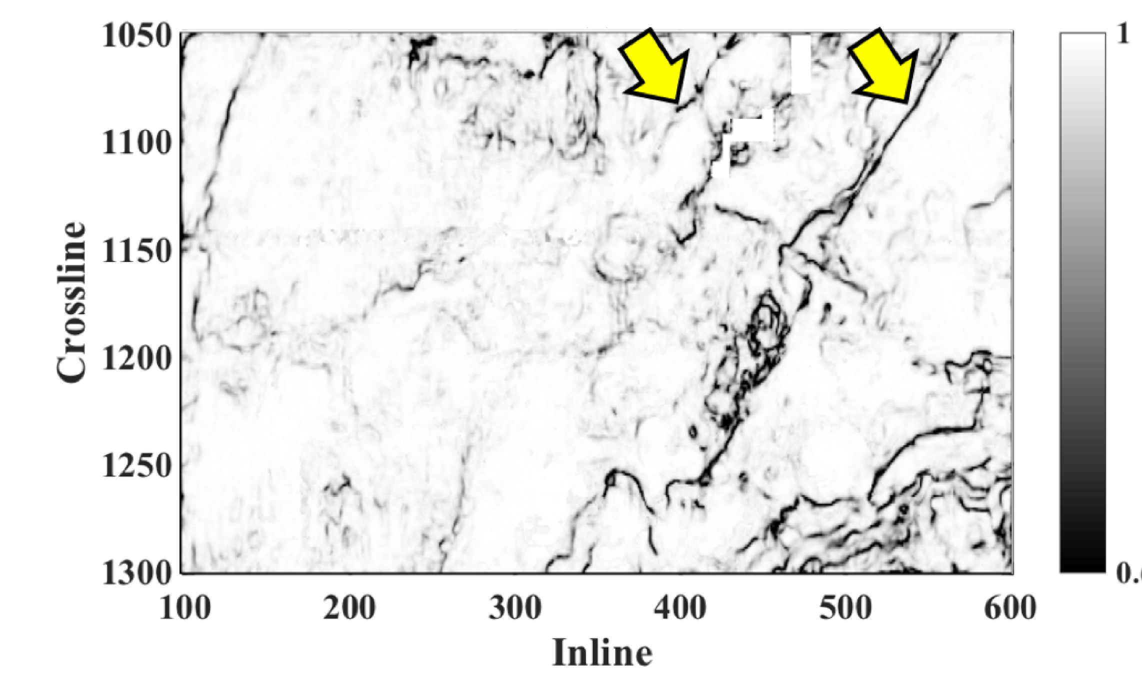

Figure 7: A horizon slice along the top PaloPinto through coherence volume after filtering.

We applied the workflow on the East Ranch data that has some steep dips and we noticed that the filtering may harm some useful signal.

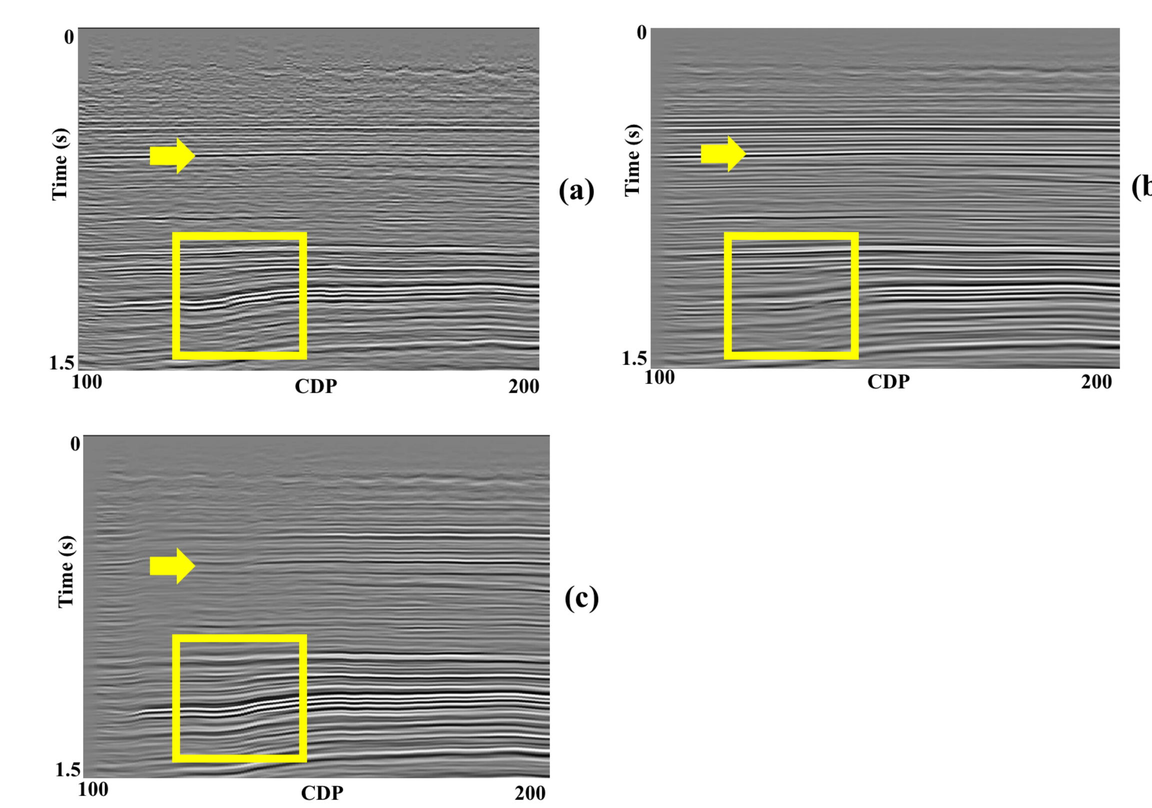

Figure 8: (a) Original seismic data. (b) Filtered data after applying the workflow. (c) Workflow applied to the data after flattinging on the dipping reflector.

Conclusion and Future work

1. The choice of number of components and espilon are critical in getting the optimized results
2. The source-receiver spacing is useful in approximating the periodicity of the footprint in kx - ky domain.
3. We noticed that a harsh epsilon can be damging for the useful structure. Currently we are trying to quantify this aspect better and controll the mask further using the dip magingutde.
4. This technique can be used to pick other periodic geological features a horizon or a strata slice.