Multichannel synchrosqueezing generalized S transform for seismic traces

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Summary

The high-resolution processing of the time-frequency analysis plays a vital role in the identification of the thin layer. Our goal is to squeeze the seismic events and separate the thin layer. Synchrosqueezing Generalized S Transform (SSGST) is a novel signal decomposition method that provides several useful characteristics by squeezing the signal and extracting the isofrequency component. However, in the real application for processing field data, this method cannot guarantee the lateral continuity of seismic data, and different isofrequency component selection has a significant influence on energy focusing effect of seismic events. We address this shortcoming of the previous method by constructing a Multichannel synchrosqueezing generalized S transform (MSSGST) method that preserves lateral continuity. And this method can adaptively extract the extremum of the frequency component which always keeps the energy of the seismic events the strongest. Moreover, this method combining the geological characteristics with multichannel data for squeezing, so it has high-resolution and continuity in both lateral and vertical direction.

Method

The equation of the Generalized S Transform is

$$GST(f,\tau)=\int_{-\infty}^{+\infty} h(t)\frac{|f|^{\gamma}}{\sqrt{2\pi}\rho}\exp\left[-\frac{(t-\tau)^2 f^{2\gamma}}{2\rho^2}\right]\exp(-i2\pi ft)dt$$

The instantaneous frequency expression of the signal in SSGST is defined as

$$\tilde{f}(f,\tau)=f+[i2\pi GST(f,\tau)]^{-1}\frac{\partial GST(f,\tau)}{\partial\tau}$$

Based on the instantaneous frequency , the Synchrosqueezing Generalized S Transform is defined as

$$SSGST(\tilde{f}_c,\tau)=(\Delta\tilde{f})^{-1}\sum_{f_k:\left|\tilde{f}(f_k,\tau)-\tilde{f}_c\right|\le\Delta\tilde{f}/2}\left|GST(f_k,\tau)\right|f_k\Delta f_k$$

We then calculate the maximum energy value of the frequency in each time point to reconstruct new data which is obtained according to the formula

$$ESSGST(f_{\max},\tau)=SSGST(\max(\tilde{f}_c),\tau)$$

We finally squeeze multichannel data in a window to get the high resolution data.

$$MSSGST_{x(n)}(f_E,\tau)=\frac{1}{l+1}\sum_{n-\frac{l}{2}}^{n+\frac{l}{2}}ESSGST_{x(n)}(f_{\max},\tau)$$

Conclusions

We propose the MSSGST for the high-resolution processing of seismic signal. Inheriting the merits of SSGST, MSSGST not only can improve the energy focusing but also enhance the continuity of the seismic events. And we can use the algorithm to calculate the maximum energy value of the frequency component adaptively that improves the universality of the method.

Acknowledgment

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Reference

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Application

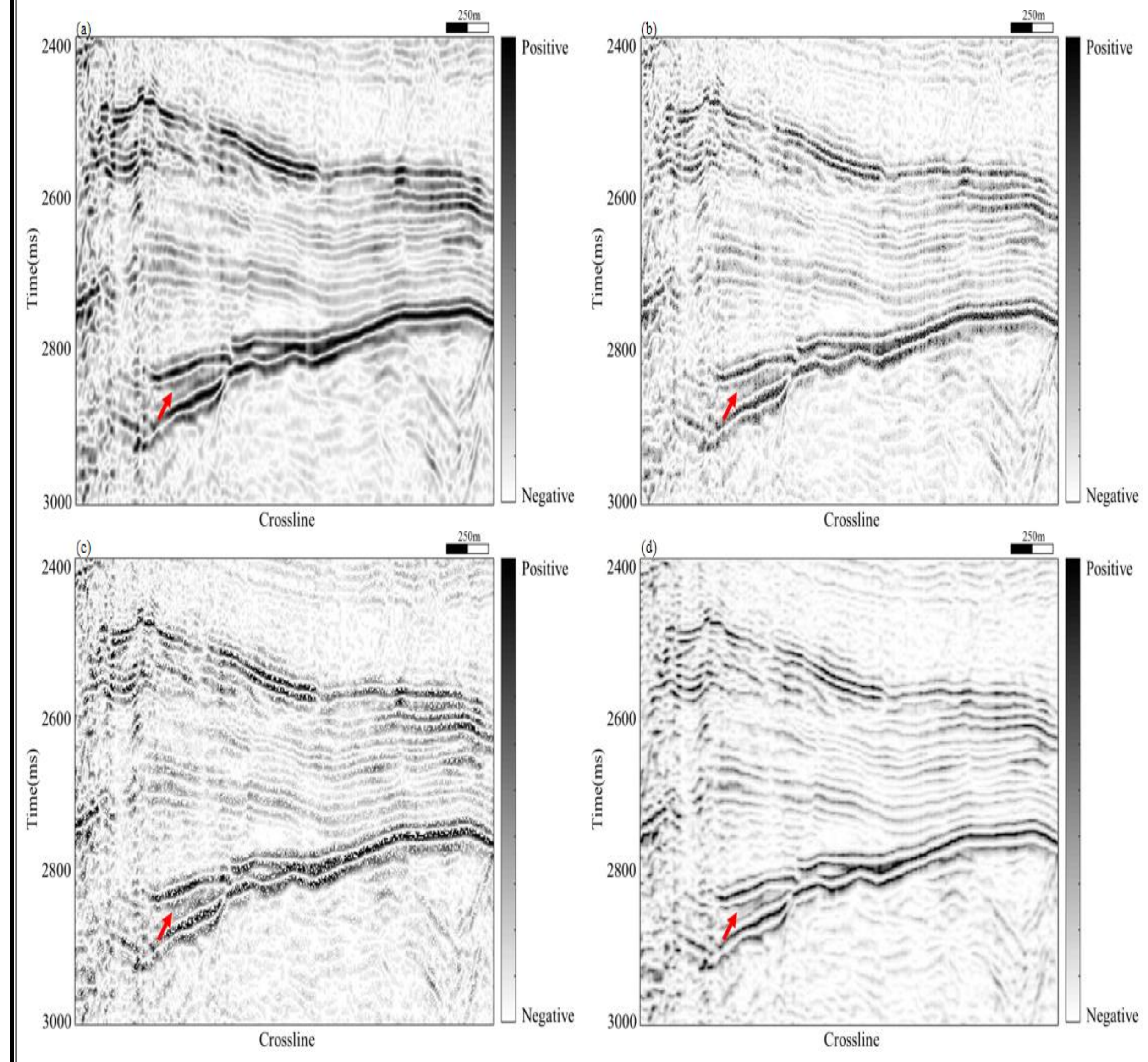

Fig. 1. Inline profile and the processed results. Note that the lateral continuity is enhanced and fine resolution is highlighted by the red arrow in Fig.1 (d).

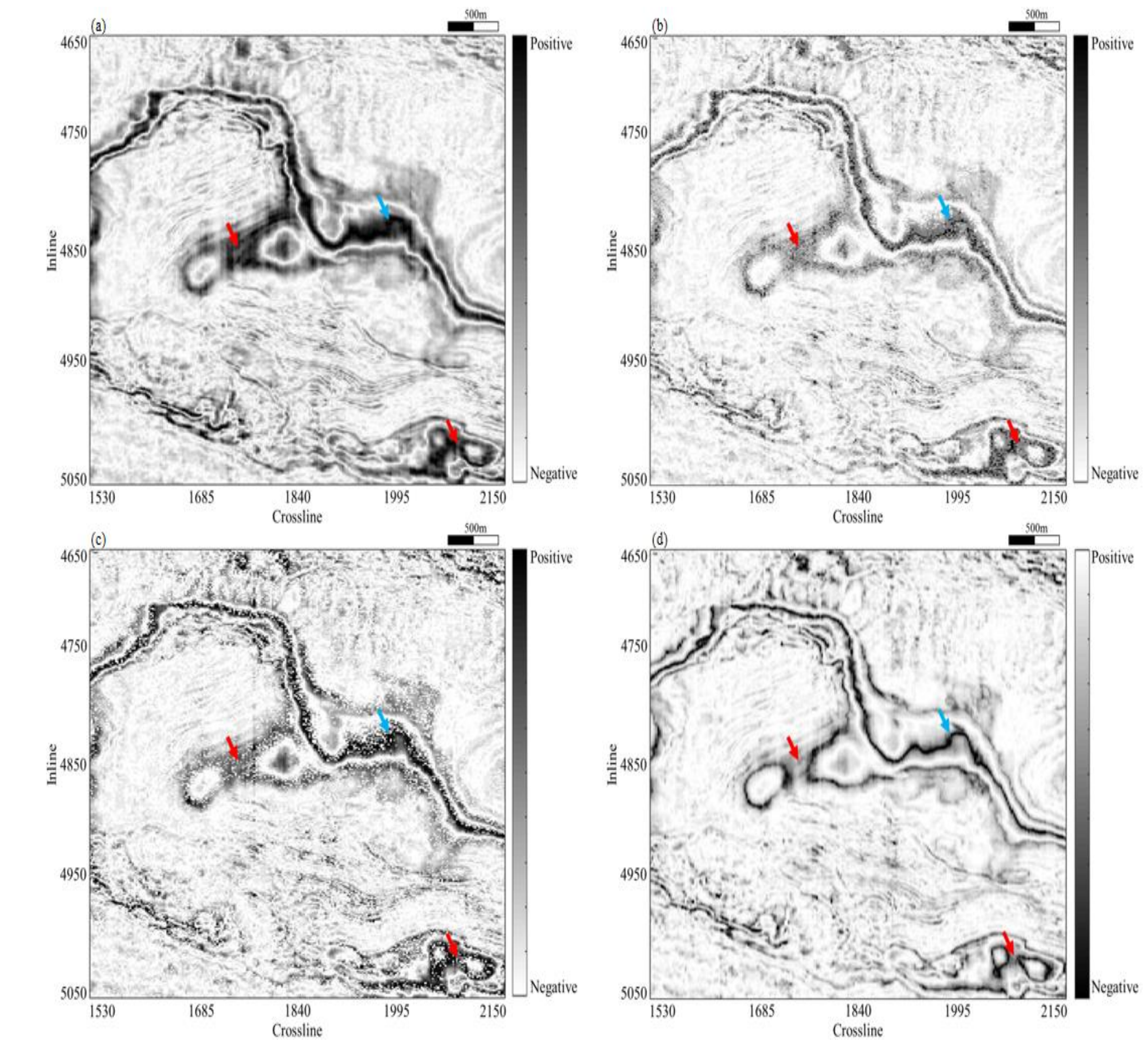

Fig. 3. Time slices of the original 3D seismic data and the processed results. Note that seismic event is squeezed and geological features are identified in Fig.3 (d).

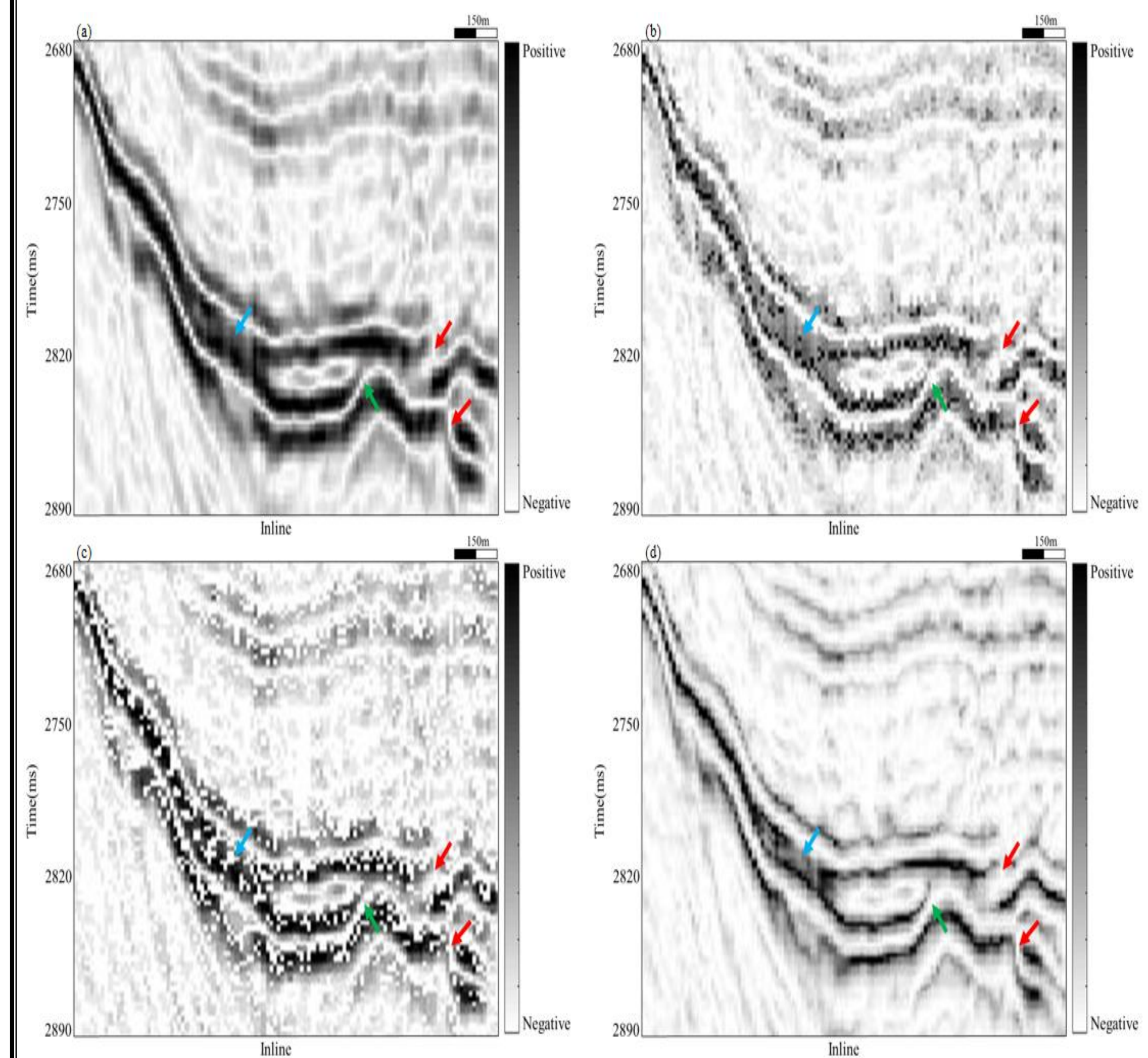

Fig. 2. Crossline profile and the processed results. Note that the lateral and vertical resolution of the seismic data is improved and the subtle geological structures are identified in Fig.2 (d).

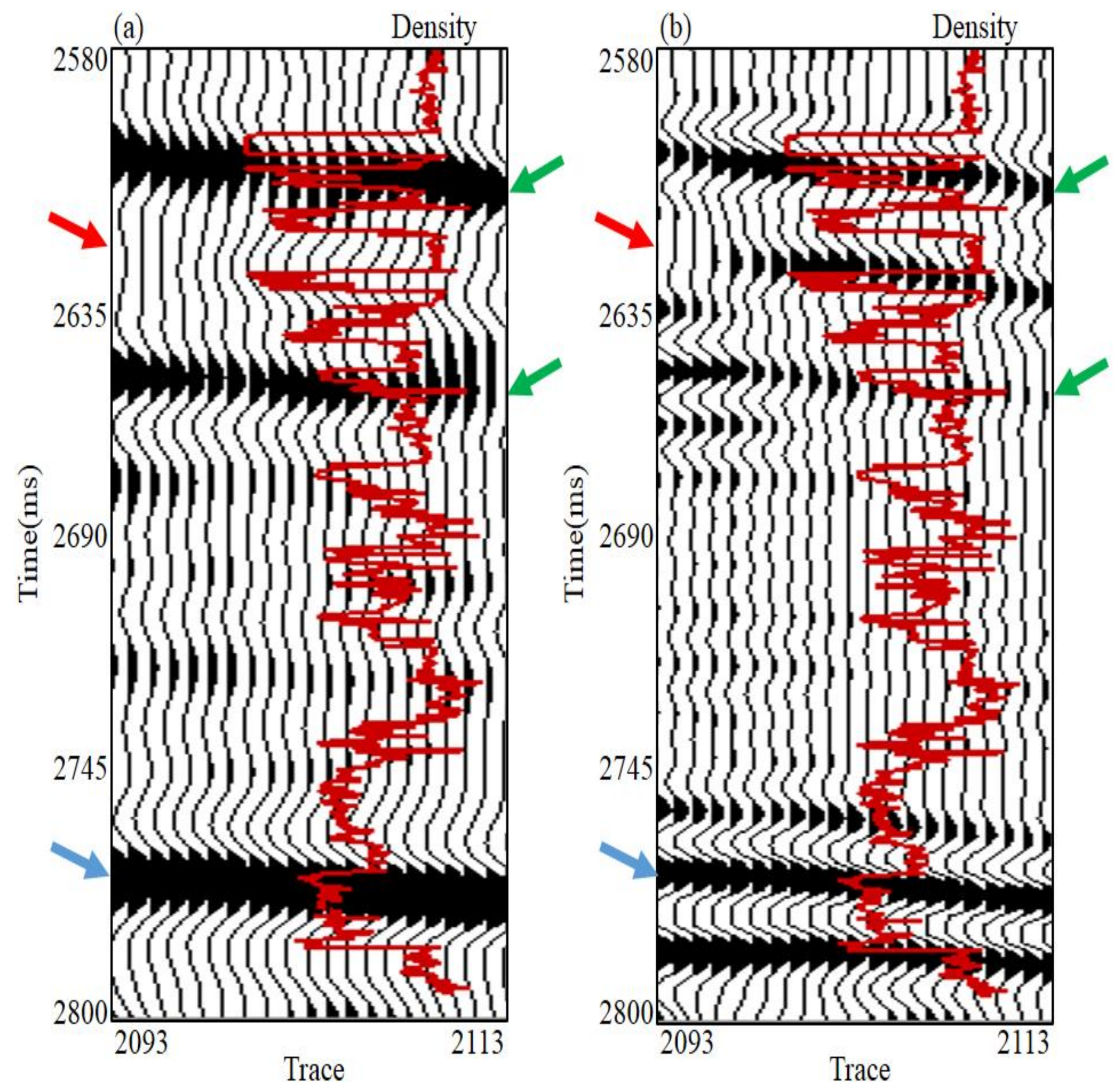

Fig. 4. The through-well profile and the processed results. Note that the seismic events in Fig. 4 (b) are squeezed, separated and it also compensates for the amplitude.