CDP noise attenuation using local linear models

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ABSTRACT

Seismic noise attenuation plays an important part in a seismic processing flow. Spatial prediction filters, like FX deconvolution, have been successfully applied to seismic volumes. However, since they require uniform spatial sampling, they are not suitable for noise attenuation of CDP gathers. A new method for noise attenuation on CDP gathers based on local linear models, is developed. The process is applied to synthetic and real data from Alberta oil sands and shows a robust performance while preserving the AVO amplitude variations.

BORGA TRANSFORM

The Borga transform is a frequency slicing method and is a particular form of time-frequency decomposition. Its computational steps are:

- Fourier transform the seismic trace
- for each frequency, window the real and imaginary parts of the spectrum with a Gaussian window
- inverse Fourier transform to get the frequency slice

NOISE ATTENUATION BY LOCAL LINEAR MODELS

The local linear models noise attenuation is based on two arguments:

- seismic signal amplitudes change in a local linear fashion in offset domain

Aki and Richards have shown us that within reasonable assumptions this is true.

- a particular seismic noise may have a narrower bandwidth compared to the seismic signal

By separating the seismic signal into frequency slices we may separate different types of noise, thus lowering the relative strength of the noise versus the signal.

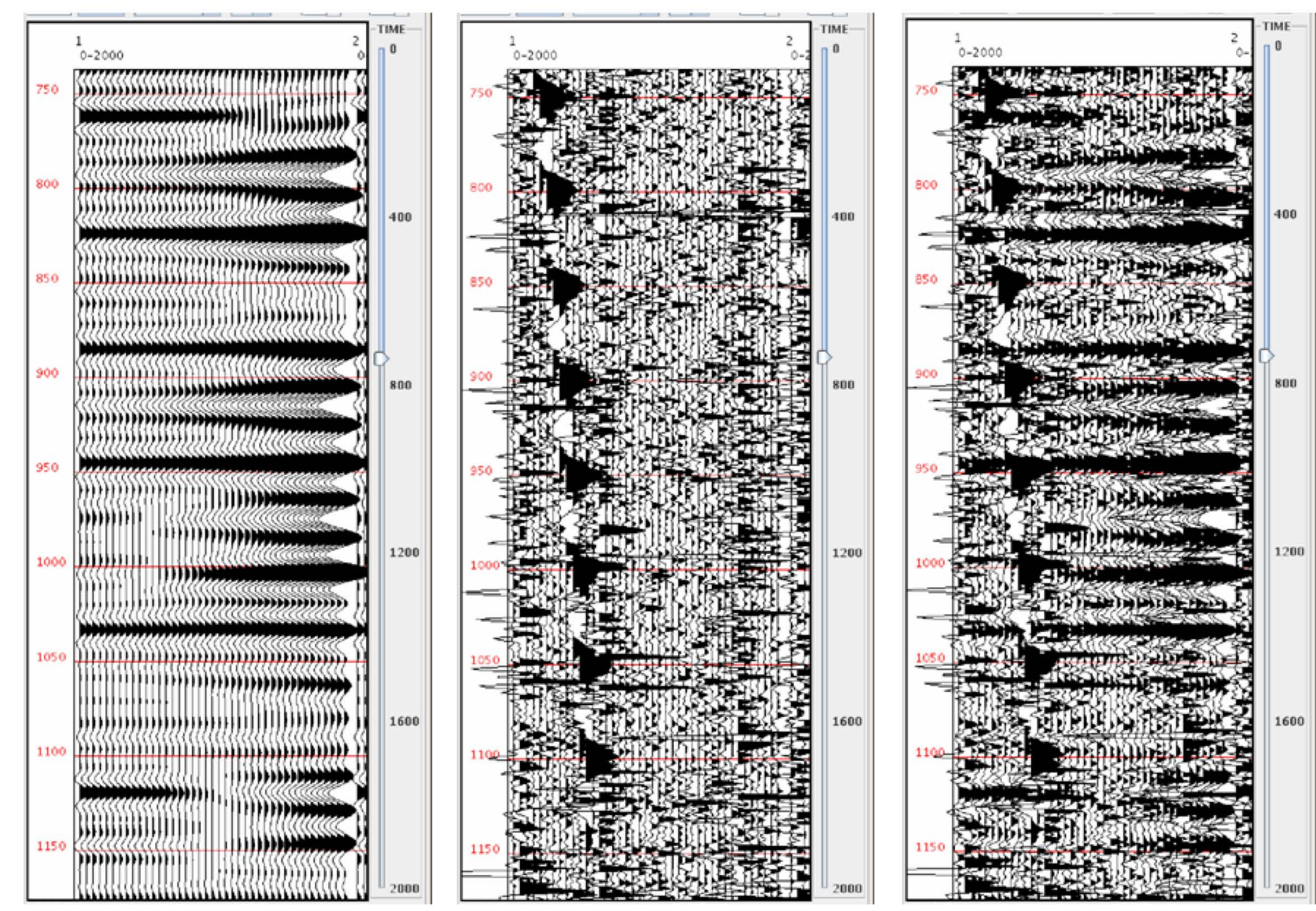
Computational steps of the method:

- start with a CDP NMO-corrected gather
- using the Borga transform, generate frequency-sliced gathers
- for each frequency
  - for each time
  - estimate the amplitudes of all samples, based on a line fit of nearby samples
  - compute the absolute error between the actual and estimated amplitudes
  - correct the amplitude of the sample with the largest error
  - repeat, if necessary

- sum noise attenuated frequency-sliced gathers to obtain the final result

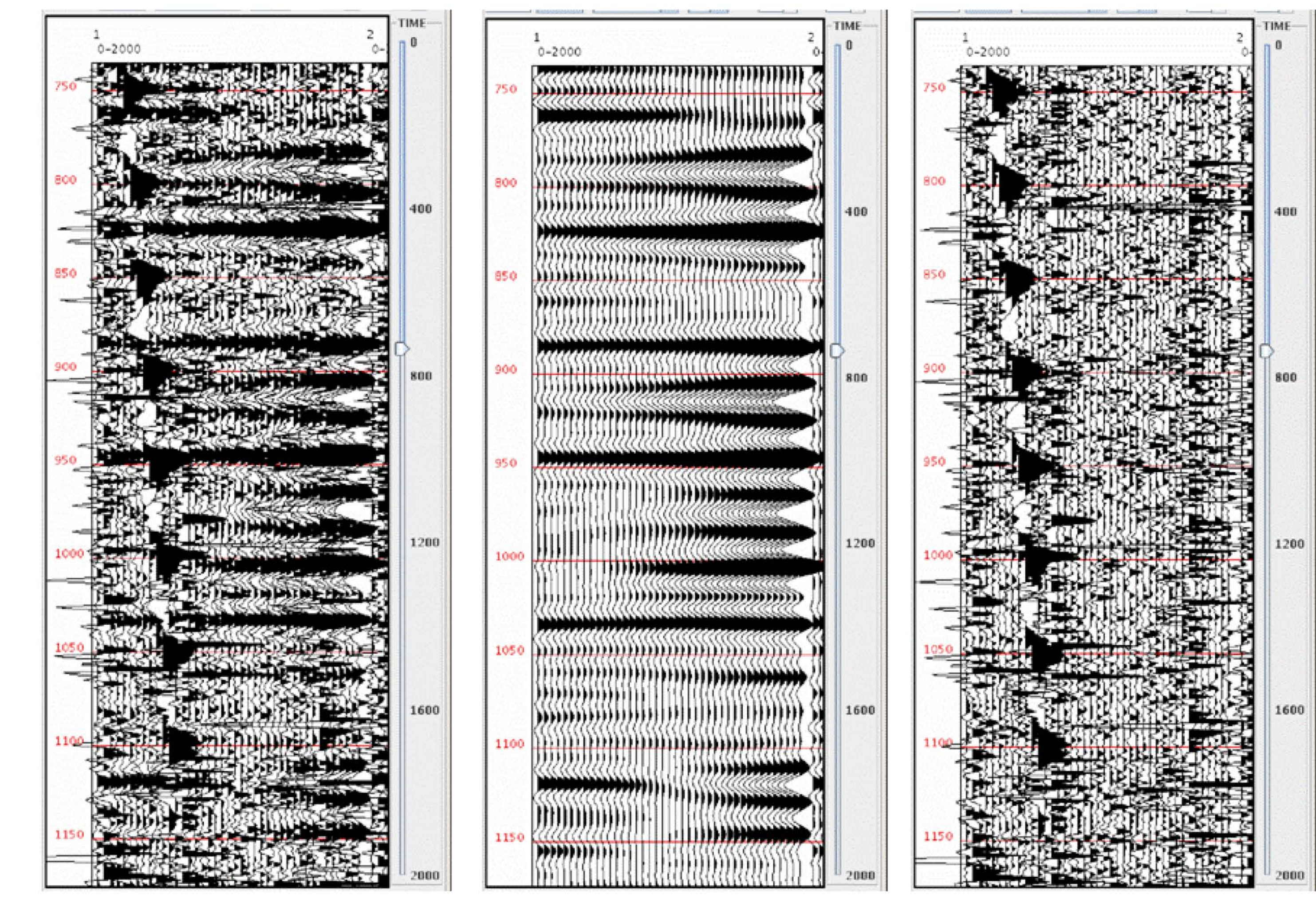
EXAMPLES

To test the method, an elastic wave AVO model, containing primary NMO-corrected events, is generated (Figure 1, a)). A random Gaussian, raised on power of 3, noise plus a low frequency linear event (Figure 2, b)) was generated and added to the AVO model (Figure 1 c)). Figure 2 shows the result of the noise attenuation process. The noise has been removed successfully and most important, the AVO anomaly has been preserved.
Figure 4 shows an NMO-corrected CDP gather from the Alberta oil sands. Figure 4 is the same gather after noise attenuation. The process has removed both: the low frequency surface wave noise on the near offset traces and the majority of the uncorrelated random noise.



a) b) c)

FIG. 1. Synthetic CDP gather with AVO anomalies a), noise added to the gather b), CDP gather with noise c).



a) b) c)

FIG. 2. Synthetic CDP gather with noise a), CDP gather after noise attenuation b), removed noise c).

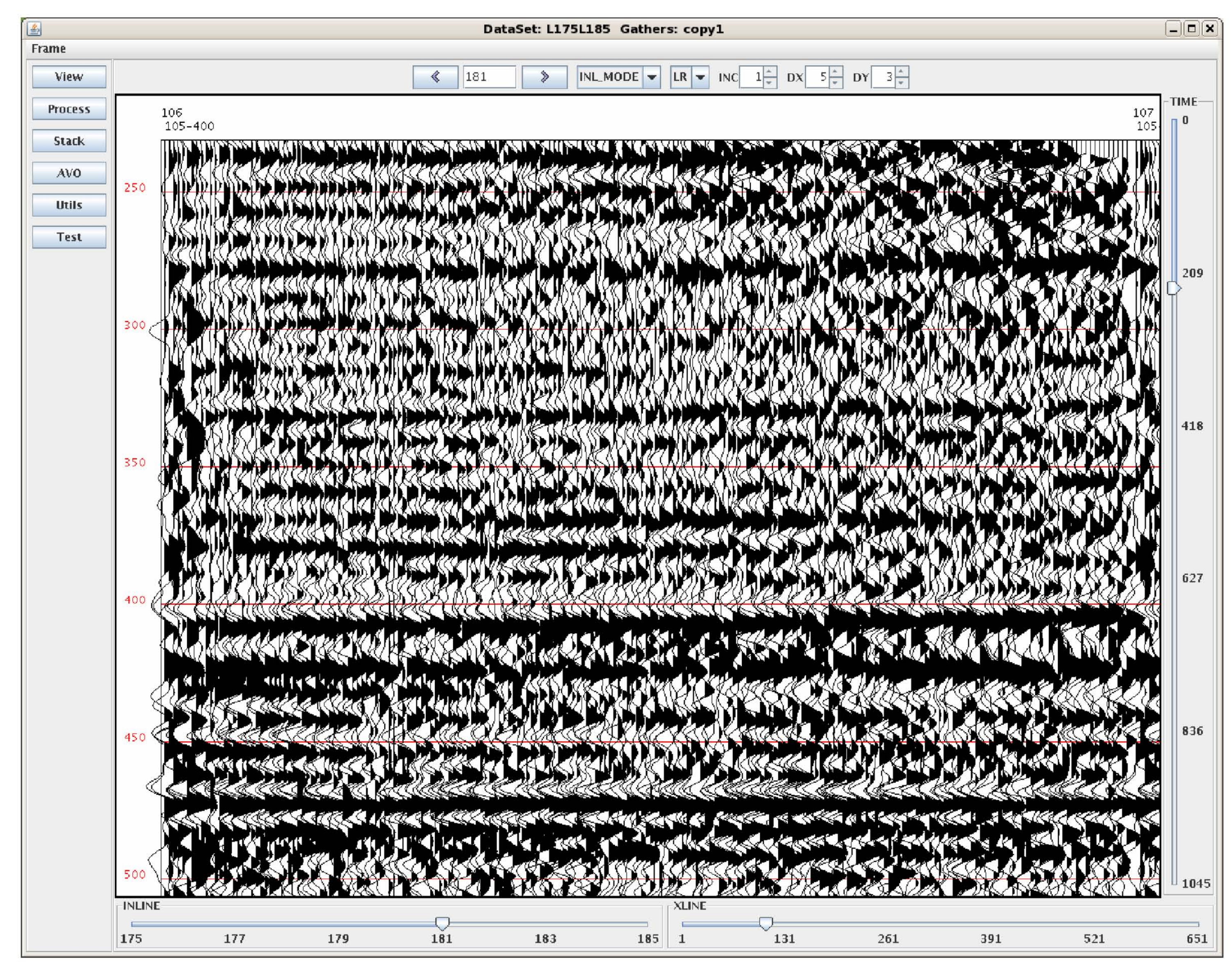


FIG. 3. Alberta oil sands CDP gather. Low frequency noise on near offset traces and random noise is present.

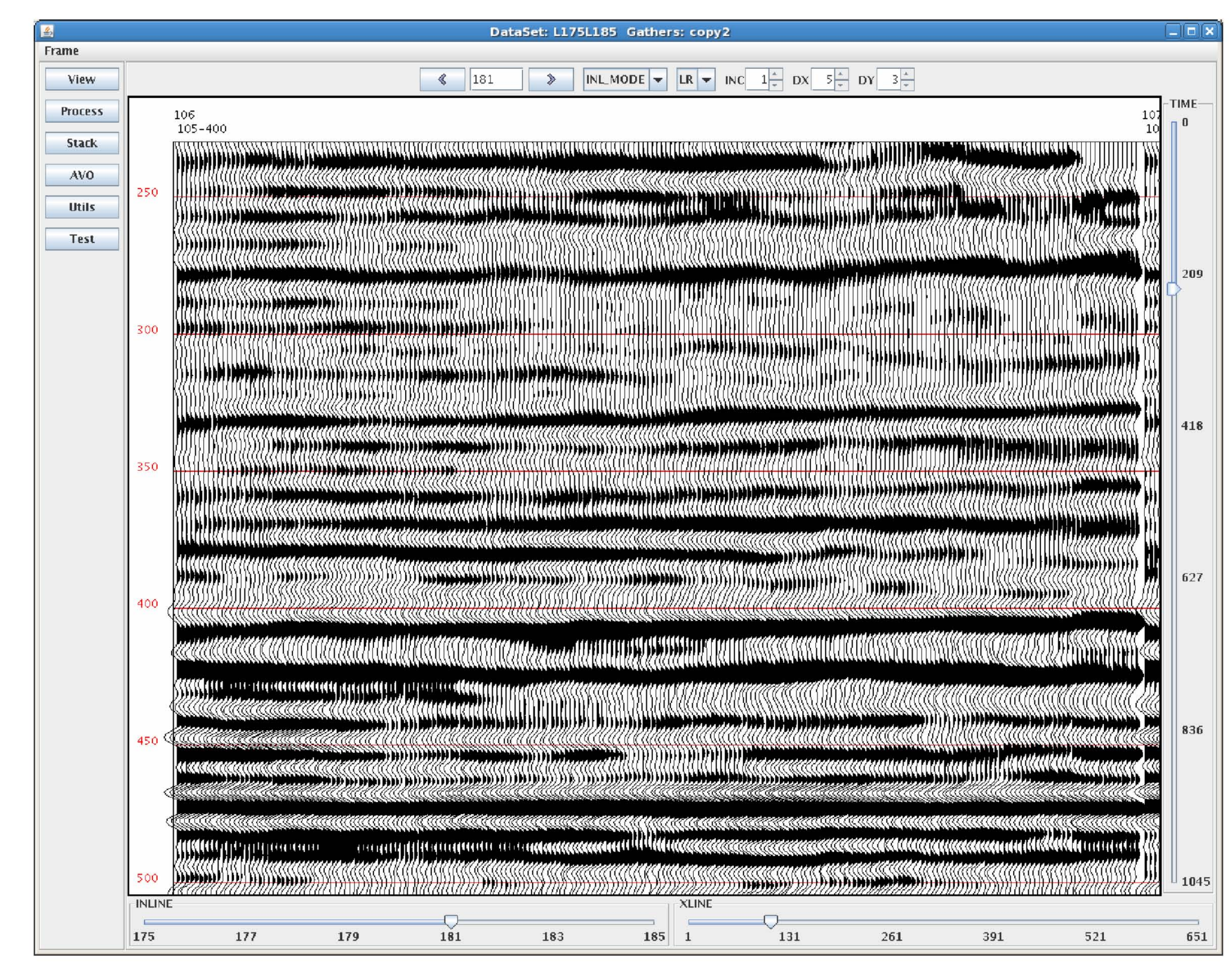


FIG. 4. Alberta oil sands CDP gather after local linear models noise attenuation. Both, the low frequency and random noise have been removed successfully.

CONCLUSIONS

The new method of noise attenuation on CDP NMO-corrected gathers in offset domain shows a very robust performance, while preserving the relative amplitude changes. From the shown examples, we can conclude that it is an effective tool for removal of low frequency surface wave noise, high-amplitude spiky noise, and uncorrelated random noise.

FUTURE WORK

The method can be extended to work simultaneously in inline-xline-offset directions for better performance especially for low fold data. The implementation should take into account the local dip of the seismic events.