Deblending of single source vibroseis land data in Egypt with V1 Noise Attenuation algorithm

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Summary

Severe interference noise that may be created with the use of slip times shorter than the listening time for single source (V1) vibroseis land data can be effectively attenuated with a modified version of the seismic interference noise attenuation algorithm (SINAT) that was developed for marine data. We call this algorithm V1NAT. We will present the application of this algorithm in the cross spread domain to a 3D data set that was recorded with orthogonal geometry in the Western Desert Region of Egypt

Introduction

Seismic data in the Egyptian Western Desert suffers from strong source generated noise such as ground roll, back-scattered ground-roll and guided waves. Previous experience in the area has shown that single source (V1) slip-sweep vibroseis recording with slip times as small as 6 seconds can help reduce the level of noise in the final section, provided that the increase in source productivity that this short slip time provides is used in increasing surface sampling density, particularly by reducing line interval (Bianchi et al., 2009). This paper is about one such 3D survey where short slip times around 3 seconds are used to increase productivity for 6 second vibroseis output times, leading to interference noise from the previous as well as the next shot and how such interference was handled in the processing center with a method called V1 Noise Attenuation (referred as V1NAT from here on) to address this noise.

Geometry of the survey

As the area of this survey needed clearing of mines left from World War II, the width of the demined corridor was kept as small as possible, hence wide areal receiver arrays could not be used. In order to reduce the number of live traces per shot and to balance the source receiver effort, a full swath roll design was used. It consisted of 21 receiver lines of length 6.9 km with shots at distances up to 3.5 km on each side of the receiver patch in the cross line direction. This geometry could be made equivalent to a centered patch of 47 lines with a roll of one line with some dropped traces and is wide azimuth with an aspect ratio of one. A linear receiver array was chosen which contained 12 geophones over 50m which did not give any protection against aliasing in the cross line direction. For this reason it was decided to reduce the source interval from 50m to 25m and reduce the slip-time from 6 seconds to 3 seconds so that total survey duration stayed the same. As seen in Figure 1, the time zone between 0 seconds and 3 seconds, where the main target is, becomes contaminated by the later parts of the previous shot when the slip time is around 3 seconds. Such contaminations are weak due to the action of spherical divergence on the previous shot. Figure 1 also shows that the level of interference is very high after 3 seconds due to early times of the next shot. The brute stack of CMPs of an inline formed from such shots (Figure 4) show that interference noise removal is needed to properly image deeper parts.

V1 Noise Attenuation (V1NAT) Method

The V1NAT method is based on a seismic interference noise attenuation (SINAT) method that was developed by Gulunay et al (2004, 2008) for 3D marine surveys. The SINAT method relies on interference noise of the other crew firing the shot records at irregular times (generally in different time windows). By working on frequency slices in small time space windows (i.e. in f-x-y domain) on a sail line, SINAT first determines which shots of the frequency slice are contaminated. Noisy shot arrays (f-x data) are firstly attenuated by a plane wave killer (i.e. prediction error filter), and then such noise reduced shot samples are replaced with their predicted values (f-y filtering) in the perpendicular direction.

The noise present inV1 vibroseis data with short slip times is different than marine interference noise in that contaminated shots are closer (generally within 500 m radius) and their arrival times are generally similar (around 3 seconds). So they almost always fall into the same small t-x-y cube that SINAT works with. The fact that actual slip time values are variable (around 3 s) helps to improve the performance of the algorithm. Even so, their attenuation is hard with SINAT type algorithms due to almost every shot in the small t-x-y cube being contaminated. However, the effectiveness of the SINAT algorithm can be increased through iterating over each frequency slice as well as over the t-x-y cube that the algorithm is acting on. This in essence produces the V1NAT algorithm used in this paper.

The results of the V1NAT process applied to the shots in the cross spread domain are shown in Figure 2. The results are uniform (reflections) from shot to shot. Indeed the difference section in Figure 3 shows that interfering weak early shots as well as strong late shots are attenuated

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adequately. The comparisons of deeper horizons in stacks of CMPs of an inline formed from original and V1NAT applied shots now show that reflectors are becoming clearer (Figures 4 and 5). The signal preservation of the process is verified observing the absence of reflection data from the difference section (Figure 6).

Conclusions

Severe interference noise that may be created with the use of short slip sweep times can be effectively attenuated with the V1NAT method discussed in this paper. Such deblended shots produce clean stacks especially at larger time zones where it was not possible to see any reflections prior to application of V1NAT.

Acknowledgements

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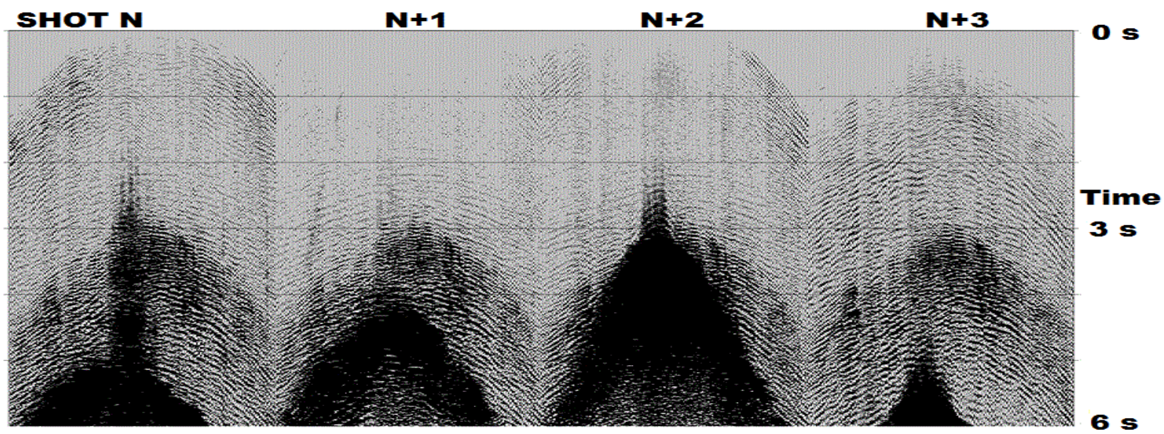

Figure 1 Shot records that were recorded with 3 second slip sweep time.

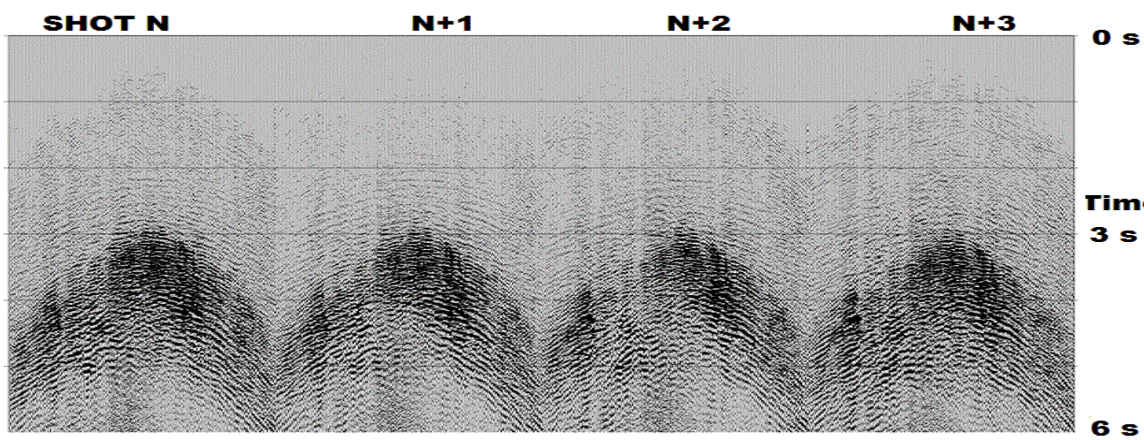

Figure 2 Shot records after V1NAT.

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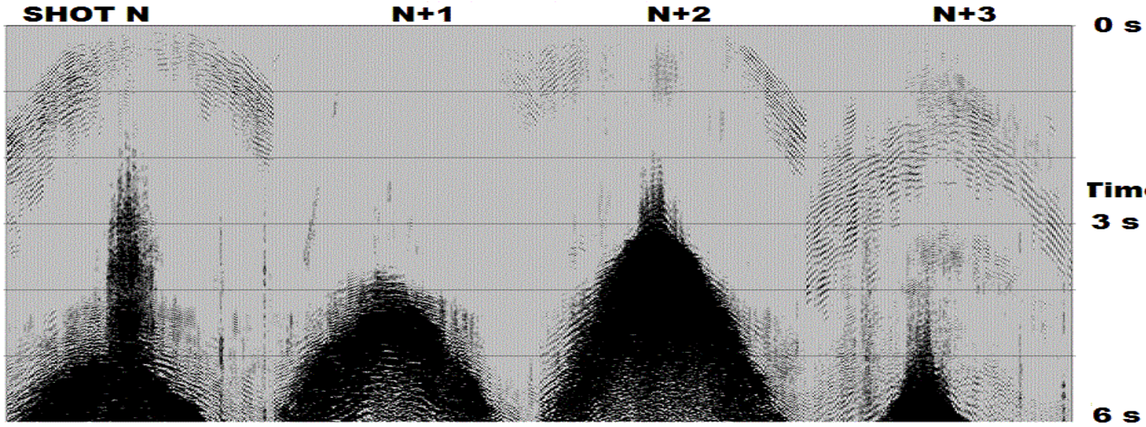

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Figure 3 Difference between input and output of V1NAT process.

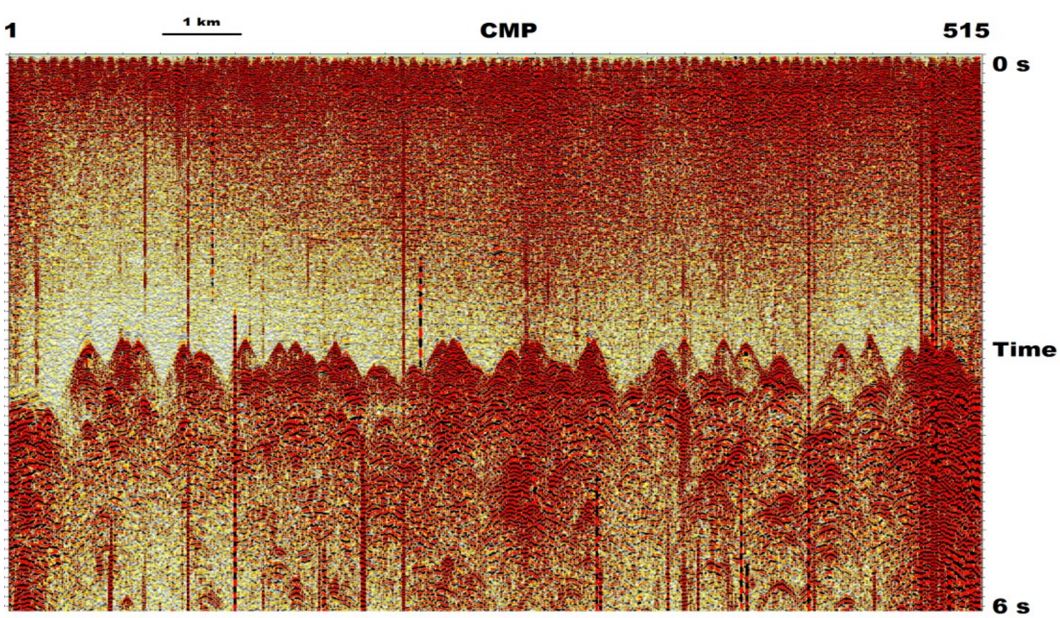

Figure 4 Stack of CMPs of an inline formed from original shots recorded with 3 second slip sweep times.

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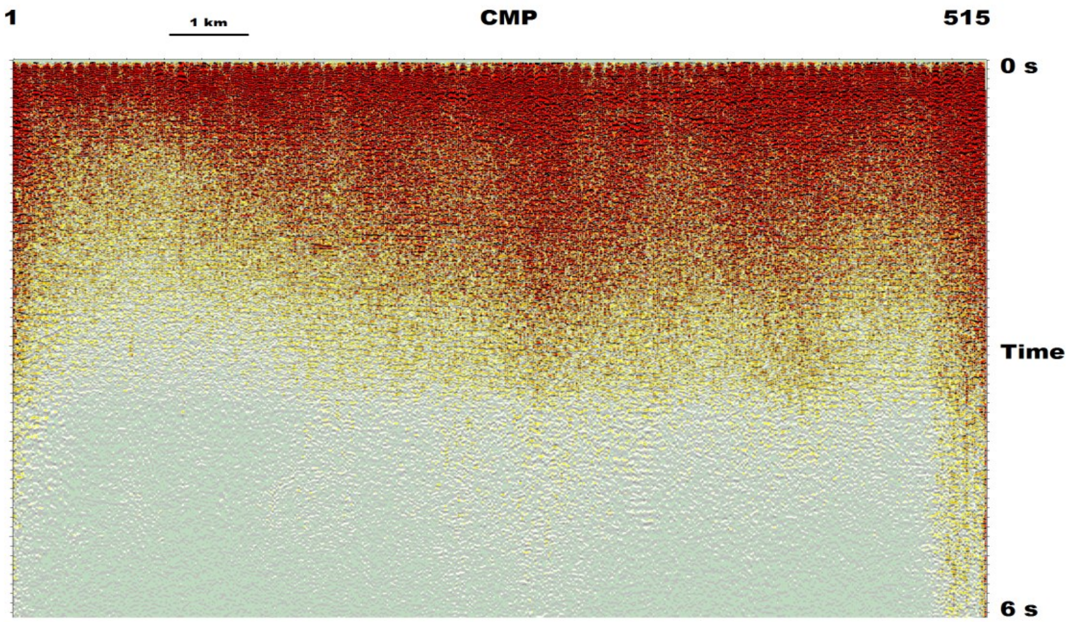

Figure 5 Stack of the same inline after V1NAT is applied to the shots.

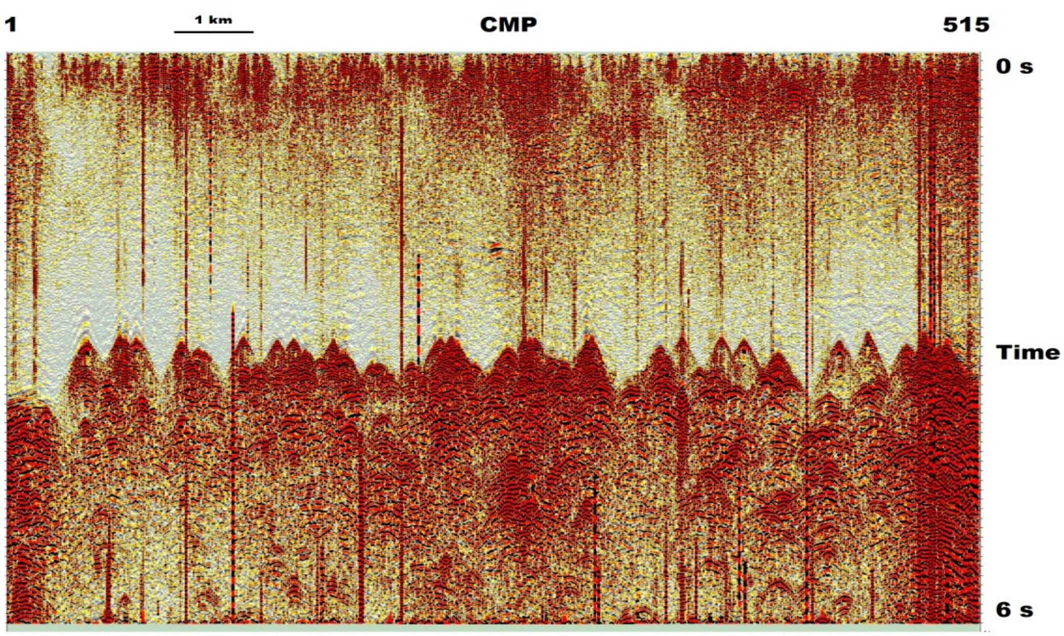

Figure 6 The difference between the stack before V1NAT and the stack after it.

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EDITED REFERENCES

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