Ice Break Attenuation on Alaska Data with V1 Noise Attenuation (V1NAT) method

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Summary

Sudden breaking of ice in permafrost areas in Alaska creates energy, known as ice breaks, on seismic data that are being recorded. Ice breaks are very strong in amplitude relative to the underlying seismic data. Depending on the time at which they hit the uncorrelated records they produce events looking differently and very strong contamination, harmful to many processes like deconvolution, multiple attenuation, or velocity analysis. Here I present a study in which I apply a tool to suppression of ice break contamination that we developed earlier for attenuating vibroseis self- contamination caused by the use of short slip-times.

Introduction

This study is undertaken with the Tabasco Vibroseis Multi-Client 3D survey that was recorded by CGG in Alaska in 2012.

The survey used 3 vibrators per group and an 8 s long EmphaSeis sweep with 4-80 Hz (Figure 1). The sweep started at 4 Hz as the low frequency end of the spectrum was of interest. The original data were recorded at a 2 ms sample interval with a 6 s listening time and 7 s slip time. The recording geometry contained 31 receiver lines at a 990/1100 ft separation, each line with 242 receivers separated at 110 ft, and 70 source lines separated at 550/660 ft containing sources separated at 27.5 ft. Correlated data were originally processed after harmonic noise attenuation (HPVA). More detail on the project can be found in Winter et al. (2013).

During these tests I did not work with the original data but a reduced version of the data to decrease the testing time. Since the spectrum is limited at 80 Hz, I downsampled the data to 4 ms. I also skipped the harmonic noise attenuation process and instead cut the recording time, knowing that harmonic noise arrives later in time and that Alaskan data decay fast with time. Hence I used only the first 8 s of the uncorrelated records for testing. These records were later zero padded (4 s) to bring them to 12 s length and correlated with an 8 s long sweep to generate 4 s long correlated data.

I show in Figures 2a and 2b how an ice break that arrives around 3 s on the uncorrelated record (2a) looks after correlation (2b). Before correlation the noise is clear in time and space and its spectrum is broad while the underlying signal (uncorrelated record) is somewhat limited in band at that time space window where the ice break contamination occurs.

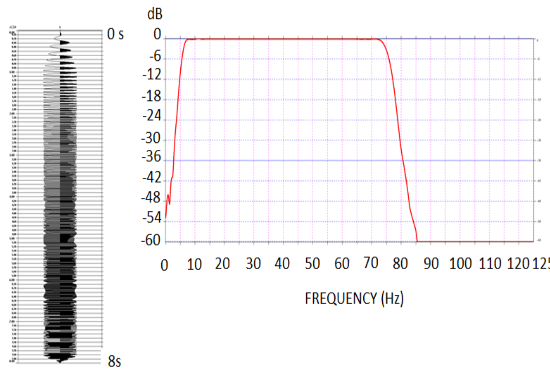


Figure 1. EmphaSeis sweep and its spectrum.

On other shots I observe that the spectral content of the correlated ice break depends very much on the time the ice break arrives on the uncorrelated record. To illustrate the point let it suffice to say that a spike (like an ice break) that arrives on the record around the end of the recording time becomes an upside down sweep after correlation but somewhat cut due to recording time generally being smaller than the sweep length, i.e., it contains the lower frequency end of the sweep but the deeper it hits the uncorrelated record the more of the high end of the spectrum the correlated spike contains. There is more spectral discrimination between the ice break and the underlying signal on the uncorrelated record than on the correlated one. For these reasons it will be desirable to attenuate ice breaks before correlation. A test comparing post correlation application of the same method is also presented.

V1NAT method and its application to ice break attenuation

In 2012 we developed a noise attenuation method for data shot in Western Desert of Egypt with single vibrator (V1) slip-sweep technique. The shot records of that survey were contaminated by future as well as previous shots since slip times were about half of the listening time for the single vibrator data. The method which is referred as V1NAT (V1 Noise Attenuation) attenuates waves which do not show coherency across geologically ordered shot records (Gulunay et al., 2013a, b). Shots of a cross spread are naturally geologically ordered. On the Egyptian survey V1NAT was applied in the cross-spread domain. Here I also applied V1NAT in this domain. Initial applications of

DOI http://dx.doi.org/10.1190/segam2014-0128.1

the method on these data were done post correlation, as was done in Egypt. As this is a threshold based process that operates in small time space gates occasional artifacts on the output records can occur which might suggest that it might be better to apply the process on uncorrelated records.

I illustrate in Figures 3 and 4 the application of V1NAT process to uncorrelated records for ice breaks that are received by the recording receiver line at late and early times, respectively. On the left of each of these figures I show an uncorrelated record, designated with symbol A. Next to it I show the result of correlation of this record with the sweep shown in Figure 1. The third figure (from the left) is the result of applying V1NAT on the uncorrelated record. The fourth and rightmost figure shows correlation of V1NAT applied to uncorrelated record.

One can see in Figure 3 a very strong ice break that arrives at the receivers at later times which is marked with a yellow ellipse (there is also some weak noise hitting receivers on the right at early times). This strong ice break becomes an upside down sweep (i.e., high-frequency end arrives earlier) after correlation as shown in Figure 2b but now it is on the whole trace. I observe that V1NAT applied pre-correlation adequately suppressed the noise and the correlation of the V1NAT-applied record looks good. The noise arriving at an early time on this record is attenuated as well.

In Figure 4 I show a strong ice break arriving at the receivers at an earlier time. Post correlation the noise is made up of mostly low frequencies occurring at shallow times. I observe again that correlation of the V1NAT-applied uncorrelated records produce clean records.

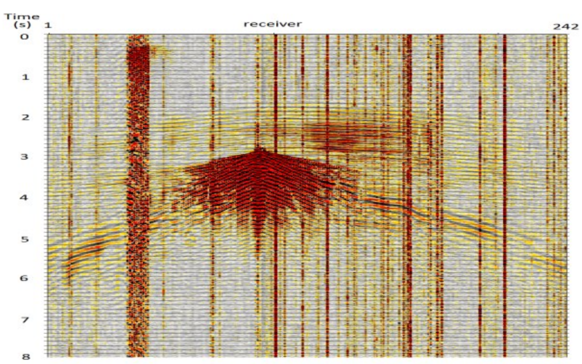
Figures 5 and 6 compare pre-correlation and post-correlation application of the V1NAT method on the records shown in Figure 3 and 4 respectively. Images represent the following: (a) Correlation of the raw record with the sweep, (b) pre-correlation application of V1NAT but after it is correlated with the sweep, and (c) post-correlation V1NAT application, (d) the difference of applying the process before and after correlation, that is (b)-(c), (e) noise attenuated by pre-correlation V1NAT, and (f) noise attenuated by post-correlation V1NAT. Note that the same parameters were used on post-correlation and pre-correlation V1NAT which may not be the best thing to do. Study of images like Figures 5 and 6 show that in some areas post-correlation application of V1NAT was able to suppress noise better but the windowed nature of the process makes noise suppressed by post-correlation V1NAT rather choppy (on and off nature) as shown in Figures 7a and 7b which are zoomed versions of Figures 6e and 6f, respectively. Obviously, post-correlation V1NAT is cheaper and more practical.

Conclusions

I observe that the V1NAT algorithm, initially developed for V1 short slip-sweep time vibroseis noise reduction can also be used successfully for ice break noise reduction. It is possible to apply the process before or after correlation with the sweep. Post correlation application might create some artifacts since the method is applied in overlapping time space gates as in fxy prediction filtering. Future tests are needed to see which one is better; perhaps once can make a strong run before and a mild run after correlation.

Acknowledgements

I thank CGG MCNV for allowing me to display the data. I am grateful to Olivier Winter (of CGG Land Research Department) for drawing my attention to the ice-break problem in Alaska and for providing me with the uncorrelated records. Finally, I thank CGG for allowing me to present the method.



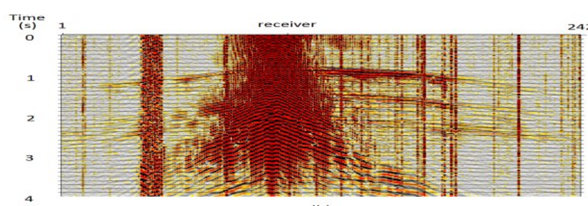


Figure 2. Ice break hitting an uncorrelated far receiver line at around 3 s (on the left) and how it looks after correlation (on the right).

DOI http://dx.doi.org/10.1190/segam2014-0128.1

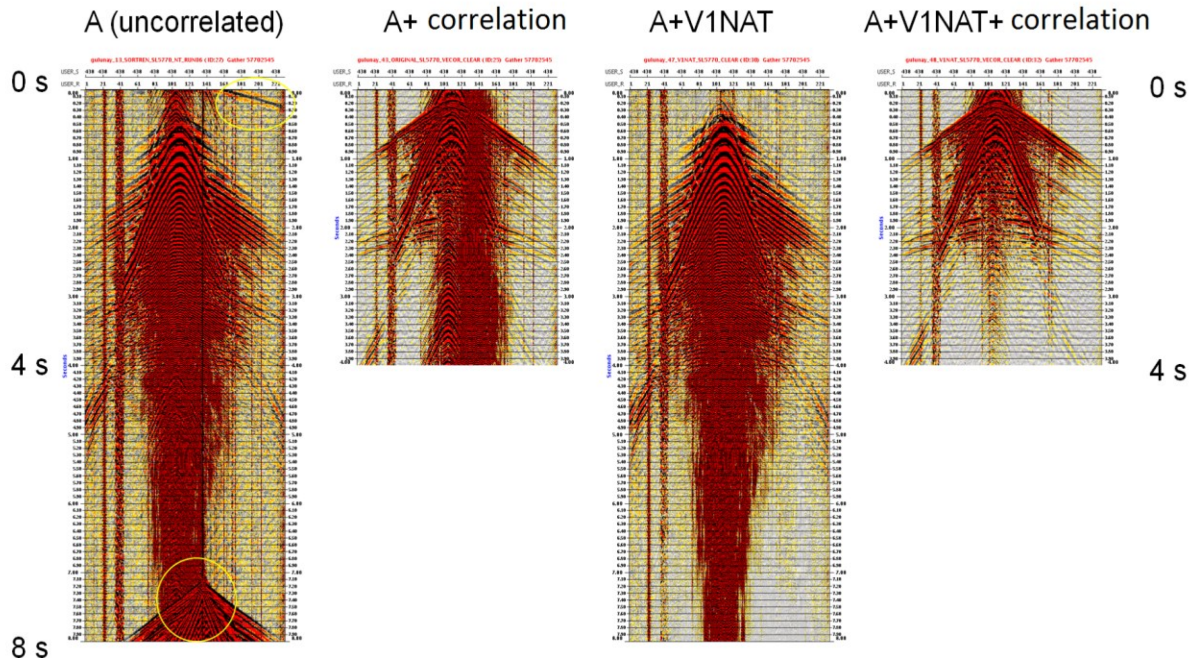


Figure 3. An ice break hitting the uncorrelated record at later times. This is effectively attenuated by applying V1NAT prior to correlation, as seen on the right hand side.

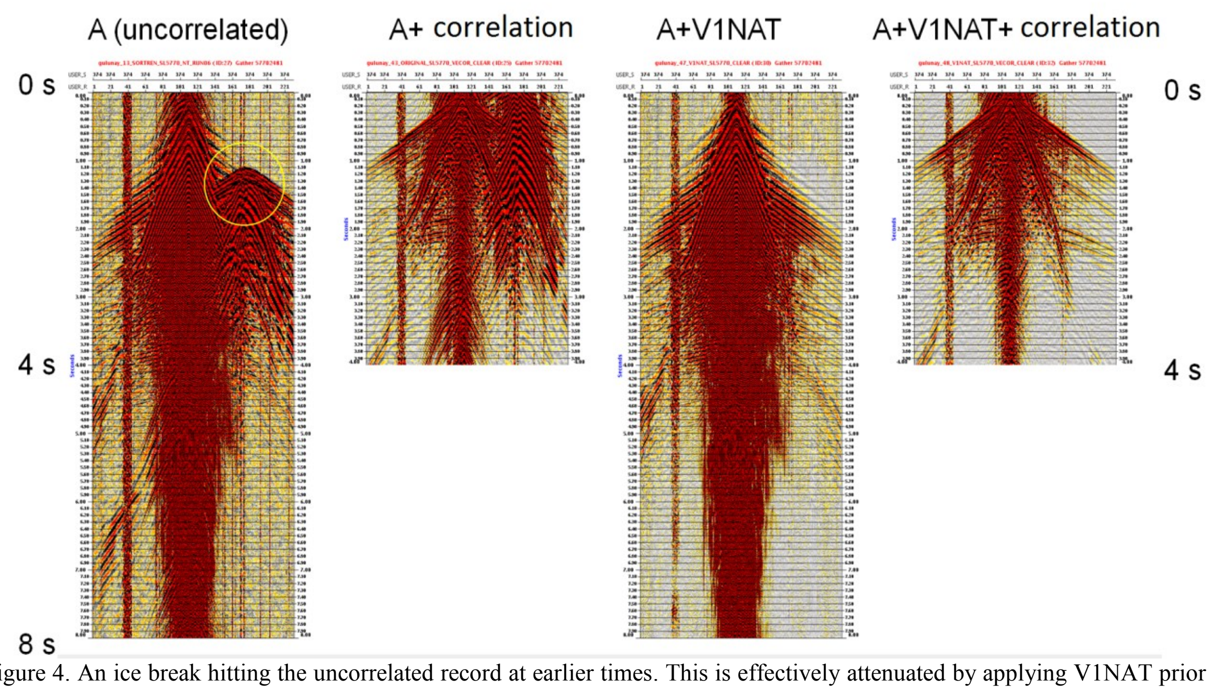


Figure 4. An ice break hitting the uncorrelated record at earlier times. This is effectively attenuated by applying V1NAT prior to correlation, as seen on the right hand side.

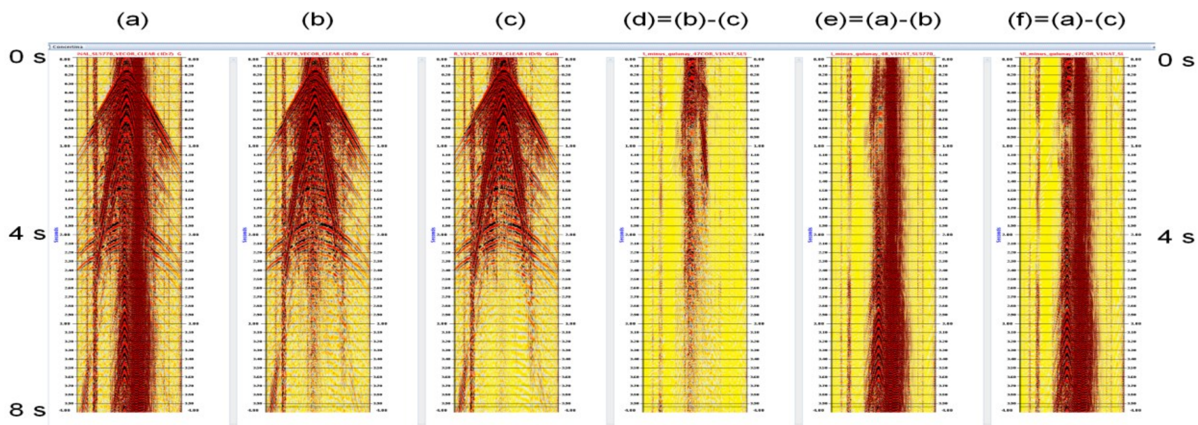


Figure 5. Comparison of pre-correlation and post-correlation V1NAT on the record studied in Figure 3.

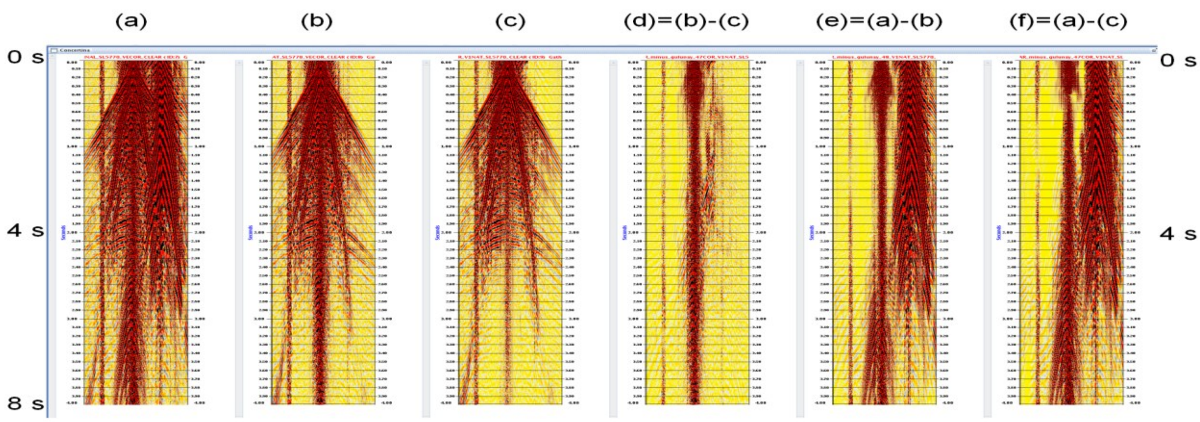


Figure 6. Comparison of pre-correlation and post-correlation V1NAT on the record studied in Figure 4.

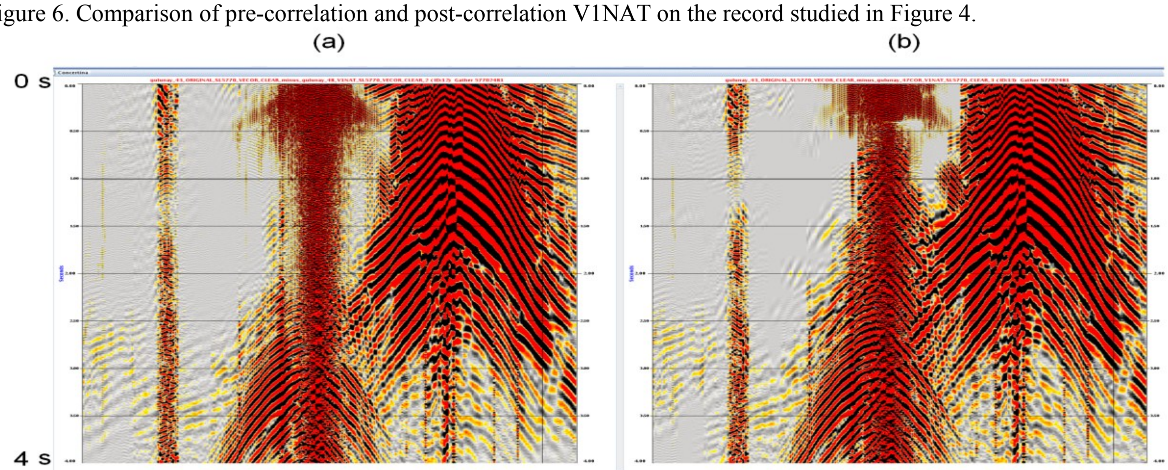


Figure 7. Comparison of noise attenuated by pre-correlation (a) and post-correlation (b) runs which are zoomed versions of Figure 6e and 6f, respectively.

http://dx.doi.org/10.1190/segam2014-0128.1

EDITED REFERENCES

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