# How to Attenuate Diffracted Noise: (DSCAN) A New Methodology

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## Abstract

Summary

Marine surveys in shallow water can suffer heavily from shot-generated scattered noise. In particular, the icy conditions of Beaufort Sea data can produce noise that can completely overshadow the expected recorded signal. This diffracted noise originates from heterogeneities near shallow sea beds. We present a method of attenuating diffracted noise in marine seismic surveys by locating the position of such obstructions using semblance scan analysis, and then by extracting the noise from the traces at the calculated travel times for each diffraction trajectory. Applications to different 3D and 2D data show the efficiency of this method.

## Introduction

Marine seismic surveys, 2D and 3D, sometimes suffer severely from scattering of source energy from sharp discontinuities at or near the sea bottom. Such scattered noise travels only in water and is much stronger than the reflection signals from deep strata. This diffracted noise interferes with many essential prestack processes, such as deconvolution, multiple prediction and migration. Its detection and suppression has been a difficult issue in research and practice of marine data processing.

One industry solution to this problem has been the execution of the following sequence (Fookes et al., 2003): (a) determine the position of one diffractor from picked travel times, (b) flatten the diffracted noise on all contaminated records, c) filter the flattened events using conventional techniques such as f-k or Radon filtering, and finally d) restore the original travel times for all the records. Typically there are many significant diffractors and sequences (a) to (d) have to be repeated for each, making the process rather inefficient.

Our motivation starts with detecting and attenuating most of the diffracted energy without picking any travel times. Our approach uses a semblance scan method called DSCAN. Landa et al (1987) is probably the first to use semblance scan to determine the location of buried diffractors in land surveys. Gulunay et al. (2005) proposed a method of automatic detection, modeling and removal of shallow water diffractors in marine surveys. This method resembles the so called “migration filtering" technique (Nemeth et al, 2000) in terms of the utilization of the double-square-root travel time equations. In this paper, we summarize the method and show its successful application to 3D and 2D marine surveys.

Diffractor position scan (DSCAN) method

The diffracted noise comes from the scattering of the source energy at the sharp discontinuities near the water bottom. The diffracted energy arrives at the receivers at a time which is the sum of the time from the source to the diffractor plus the time from the diffractor to the receiver:

$$T = \frac{1}{V}\sqrt{(x_s - x_d)^2 + (y_s - y_d)^2 + z_d^2} + \frac{1}{V}\sqrt{(x_r - x_d)^2 + (y_r - y_d)^2 + z_d^2}$$

where V is the velocity of propagation. Given a diffractor point $D=(x_d,y_d,z_d)$, in an area (x and y range), the amplitudes of data at time T calculated as above for all traces ( i.e. source $S=( x_s , y_s)$ and receiver $R=(x_r, , y_r)$ pairs ) can be used to compute the coherency of the diffraction generated by that diffractor location. Stack amplitudes, or stack power, could be used to estimate how strong this diffractor is. Semblance is used as the coherency measure, and one could use other measures as well. We use the best estimate of the water velocity for V and generally assume $z_d=0$ for shallow water cases. Note that given the finite record length (typically from 5 to 14 seconds) and for a given shot record there is a finite area that one needs to scan to find the diffractor locations that are affecting that shot. Once semblance scans in the x and y range are completed, the most coherent points (diffractors) can be automatically selected, and for each such point the travel times to a receiver-shot pair (trace) can be calculated. A short wavelet around this time can be extracted from that trace to obtain the contribution of this diffractor which will later be subtracted from the input record to obtain the noise attenuated record.

Field data examples

We have tested this method on a number of marine surveys. Here we would like to present two of them: the first one is a sailline from a 3D survey with 3 streamers per shot, the second one a 2D survey with one cable. A typical noisy shot from the 3D survey is shown in Figure 1a. Close inspection of the shot record suggests that there are a few diffractors but it is not easy to predict how many or which event belongs to which diffractor.

The semblance scan of this shot and another one next to it, using a scan area of 11km by 12 km are shown in Figure 2. We used V=1538 m/s in the scans. The red colour indicates semblance values above 0.08. The highest semblance value found in the search was 0.53. There are holes in the middle of the semblance distributions shown in Figure 2. They are due to the fact that the first second of the data was not included in the diffractor scans. The missing parts from the semblance scan on the broadside are due to the fact that cyclic (low frequency) reflectors may look like broadside diffractors, especially when the number of cables per shot is small. Such points may need to be excluded from the analysis to protect reflection energy. Note the consistency of diffractors between two shots. Diffractor selection can be made using local maxima criteria with thresholding.

Figure 1b shows the noise model built from the first 22 strongest diffractors chosen from the scans like Figures 2. This model can later be subtracted from the record either by straight subtraction (Figure 1c) or by least squares subtraction, if desired.

Figure 3a, 3b and 3c show, respectively, the stack of the raw record, the stack of the noise model generated by DSCAN in 35-375 Hz range, and the stack of the noise reduced records for the 2D shallow marine high resolution survey (Nyquist frequency=500Hz). The diffractors on this line were mostly broadside diffractors and are therefore undesirable for a 2D survey. Depending on the azimuths, the diffracted noise can have almost any shape within shot gathers. These diffractions are so strong that they indeed leak into the stack as seen in Figure 3a. The stack of the noise attenuated records (Figure 3c) show that most of the diffracted energy is attenuated by our method. The remaining noise has lower frequency content (0-35Hz) and is due to its exclusion of this range for reflection protection during noise model building.

## Discussions and Conclusions

We have presented an automated method for attenuating diffracted energy from shallow water inhomegeneities that are harmful to marine surveys. The method uses the double square root travel time equation and in essence is a migration/demigration type process except that it uses semblance instead of stacking amplitudes at constant depth (e.g. $z_d$=0) and applies signal processing methods to build the noise model instead of a demigration process.

Seismic recorded in the MacKenzie Delta suffers from this and another common near surface noise: ice fractures. These noise bursts travel in the locally nearly constant velocity permafrost. An adaptation of DSCAN to deterministically attenuate direct arrivals can automate the heavy task of noise removal in these areas.

## Acknowledgments

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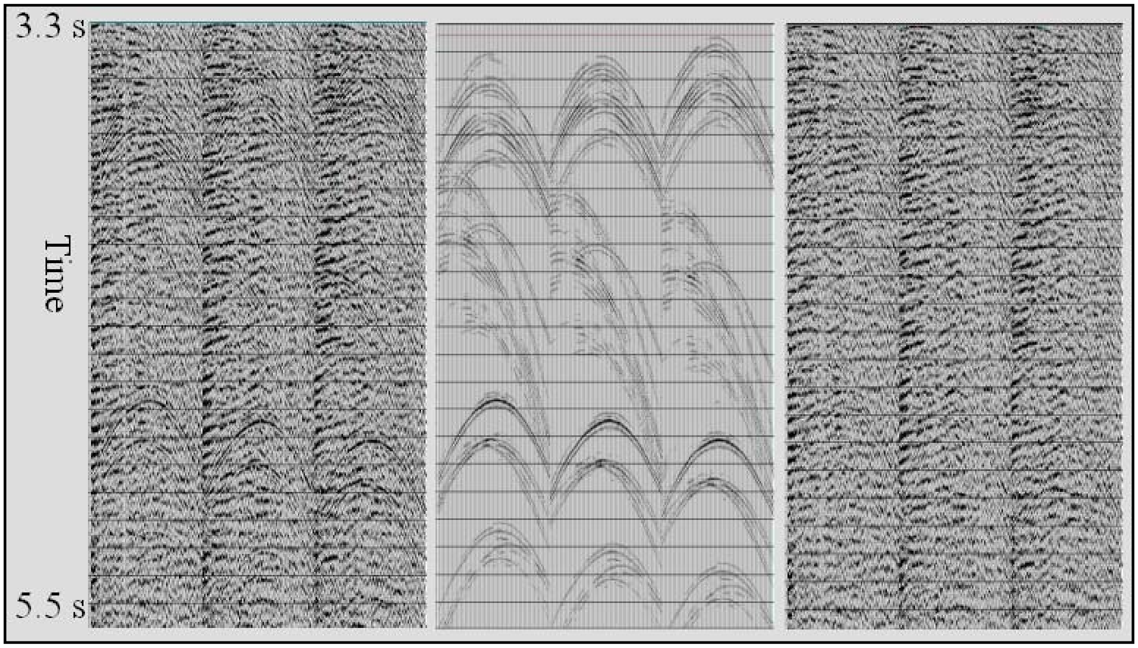
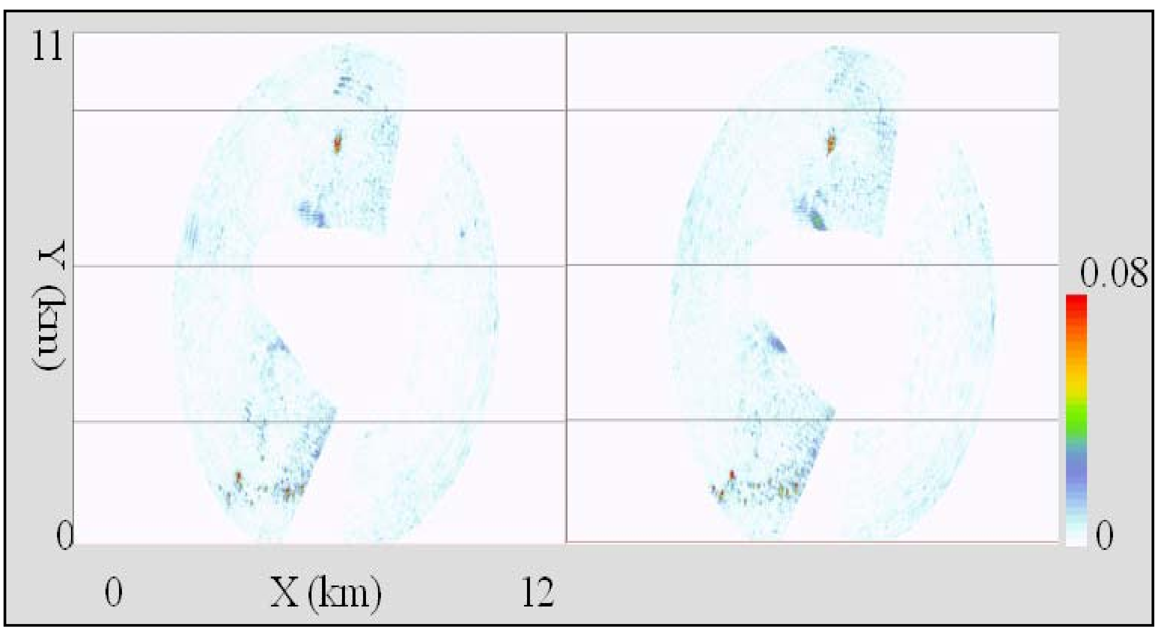



(a) (b) (c)

**Figure 1. A shot gather with 3 cables**
**a) input contaminated with diffracted noise**
**b) diffraction model built, and**
**c) after direct subtraction of noise model from the input.**




(a) (b)

**Figure 2. Diffractor semblance scans for two consecutive shots (a and b). Each scan covers an area of 11 km by 12 km.**

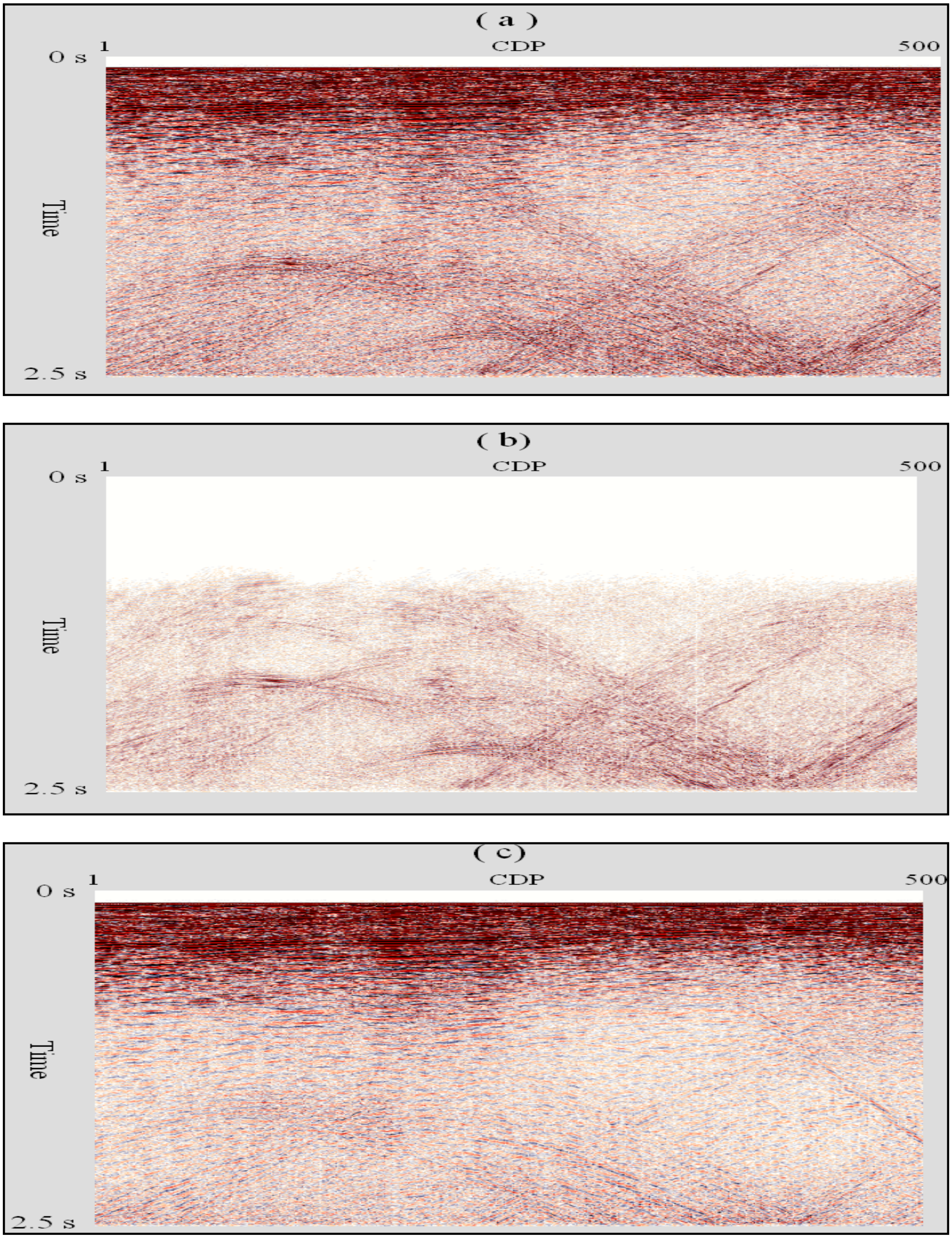



**Figure 3. Stack of a 2D line; a) initial, b) diffracted noise c) noise reduced**.