



Attenuation of High Amplitude Noise in Pre Stack Data and Preservation of Relative Amplitude -A Case Study

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Summary

The problem of attenuating noise on seismic data has received considerable attention throughout the history of seismic processing to enhance the signal to noise ratio. The presence of high amplitude noise especially in the land data due to noise bursts, cultural noise, air blasts, and transmission error, corrupts the dataset and leads to less reliable end product. Here we discuss spatial amplitude scaling technique and its effective implementation to attenuate these types of high amplitude noise. The amplitude of a trace in a small temporal window is compared with that of the neighbouring traces. Noisy portions of the trace with anomalously high amplitudes in the spatial window are scaled down while preserving the relative amplitude in the data. This method has been successfully tried on different data set pertaining to Cauvery Basin.

Introduction

What exactly is noise? According to Hampson & Russell – “it is anything on the seismic data that does not fit our conceptual model of the data i.e. as clean seismic reflections” (TLE-Oct. & Nov. 1990). The noise predominantly seen in the land data are due to logistics, cultural, power line, transmission error etc. Clean pre-stack gather with enhanced signal to noise ratio is an essential pre-requisite for appropriate velocity estimation for migration and AVO studies. In order to achieve this, it is to be ensured that high amplitude noise and other cultural noise which are often unavoidable during land data acquisition has to be attenuated during the initial stages of processing.

This method has been tested successfully to identify and attenuate the high amplitude noise in the datasets of Cauvery Basin, where pre-stack migration has resulted an improvement in sub surface imaging compared to earlier data. In this process, utmost care has been taken for selection of parameters so that there is no loss of signal at any stage of processing. A difference plot has

always been taken for QC purpose. The relative amplitudes of the primary reflections have always been preserved during the whole process.

This was ensured by checking the amplitude curves at each stage of noise attenuation with respect to offsets to retain the same behaviour.

Input Data

Shot gathers of 3D surveys pertaining to Cauvery Basin (location map shown in Fig:1) were chosen for application of this technique for the effective attenuation of high amplitude noise bursts and cultural noise dominant in the data. Difference plots have been taken in each stages of noise attenuation to to check the loss of signal, if any for QC check. The field data is loaded in the system after internal format conversion. The shot sequence data is taken into consideration for noise in different stages.

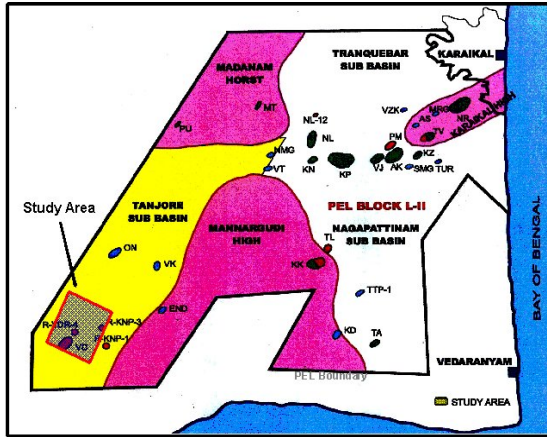


Fig-1: Location map of the area under investigation

Removal of Dead Traces

Before noise attenuation, it is required to eliminate the dead traces present in the dataset. Dead traces are identified as zero or near zero average amplitude traces consistently over different time windows.

Theoretical Background

The dataset in gathers is analyzed across small overlapping spatial and temporal windows by comparing the window amplitude with the amplitude of corresponding window on neighbouring traces in the data. For each trace and each time gate median RMS amplitude is found from the amplitudes of corresponding gates in the neighbouring traces in the dataset.

Only nonzero samples are used for computation of the amplitudes. The median is compared to the gate amplitude in the trace. If the trace gate amplitude exceeds a pre defined threshold amplitude, which is supplied by the processor, the trace gate is scaled down to specified amplitude.

The threshold is the median multiplied by a factor. The target amplitude equal to zero will result in zeroing the output in the gate.

The window size is selected depending upon the temporal length of the noise problem in the dataset, say 200 ms. A large window is taken for no significant noise problem where small windows are chosen where the data is noisy. A scalar is computed for each window. The first window begins and ends at the specified start and end time of the gate with the following windows beginning at half the window length of the previous window. The whole time range of the data is used with overlapping time windows in calculating the scalars. The first breaks normally have high amplitudes which can overshadow otherwise the anomalously high amplitudes in the reflections. For this purpose, offset dependant spatially varying time windows have been used to ignore the first break.

This works well if the noisy traces are scattered evenly within the record. A bunch of consecutive noisy traces may pass 'unhurt' by the process. Such a situation can be handled by the application of the process in different domains like Shot-Channel, Shot-Offset, Receiver-Offset, CDP-Offset or arbitrary domain like Shot-mode (Chan, 10) etc. The idea is to obtain a favourable statistics to detect the noisy traces. A bunch of traces in one domain may appear scattered in other domains.

Number of traces in the median calculation and the threshold for identification are the two important parameters input in this process. They need to be chosen judiciously to preserve the genuine amplitude variations, if any, present in the record. Less number of traces with high threshold will result in minimum processing.

Advantages

1. The process is applied in time domain. Therefore there is no domain transformation.
2. The process attacks only on the noisy parts of the traces leaving the signal untouched.
3. It does not kill or omit traces.
4. Amplitude variation across traces due to geology can be preserved easily.

Field Data Example

Fig-2 shows the result of application of the process on representative raw shot gathers from a 3D data set in Cauvery Basin (ref. fig-1) which was considered for study. Here the process is applied on the raw shot gather (A) in shot-channel domain, the output is shown in B after noise attenuation, where (A-B) is the difference plot i.e. noise attenuated by applying this process. Fig-3 shows a zoomed view of a portion of the shot gather after first pass noise attenuation process.

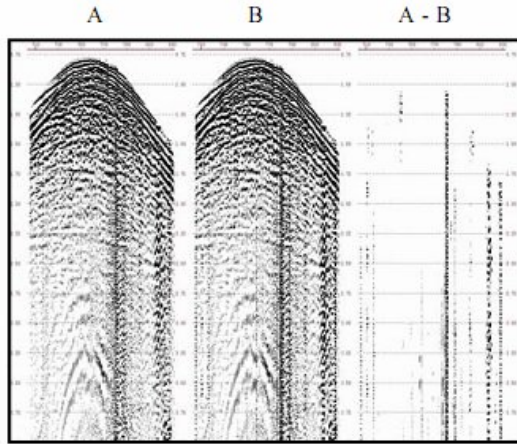


Fig-2: Noise attenuation in first pass

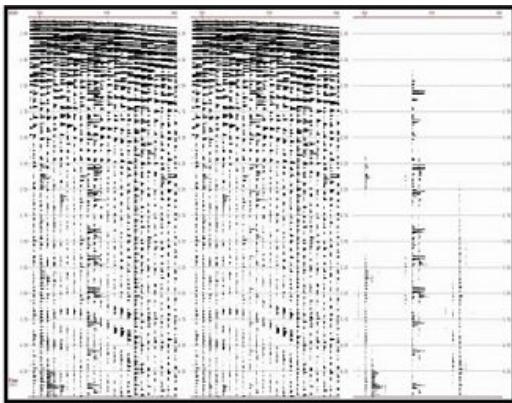


Fig-3: A zoomed view of a portion of the shot gather

The shot-channel output thus obtained is sorted in shot-offset mode and the process is again applied. Fig:4 shows the raw shot gather in A, B is the output of this process and a difference plot is taken for QC purpose. It is seen that few noisy traces have been removed in this domain which could not be removed in shot-channel domain.

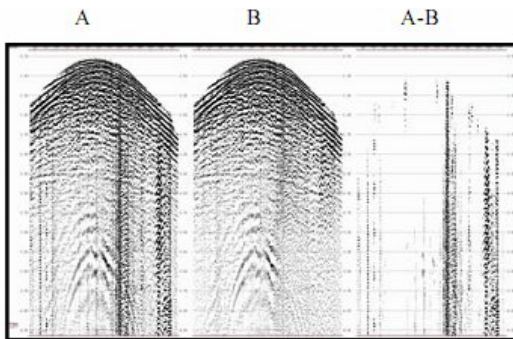


Fig-4: Raw gather vis-à-vis noise attenuated gather after second Pass

Now the processed output in shot-offset again sorted in receiver-offset domain and taken as an input for the next process. Fig-5 shows the final output, input & the difference.

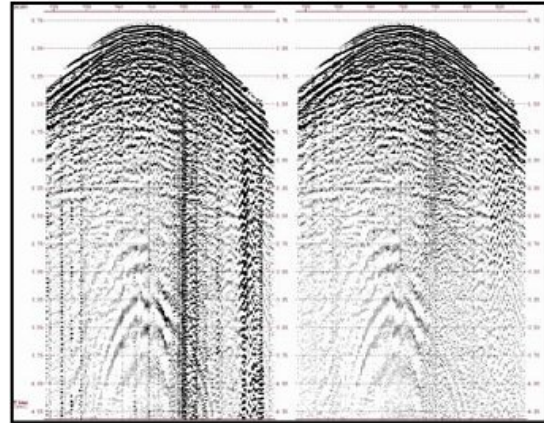


Fig-5 : The final output before & after noise attenuation

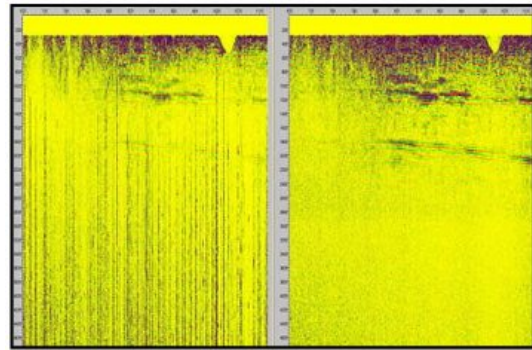


Fig-6: Stack comparison before & after noise attenuation

Fig-7 & 8 shows the amplitude spectrum before and after noise attenuation. It is evident from above figures that after attenuation of high amplitude noise in the gather, the signal to noise ratio is improved by the removal of the unwanted high amplitudes which would otherwise have contaminated the data in further course of processing.

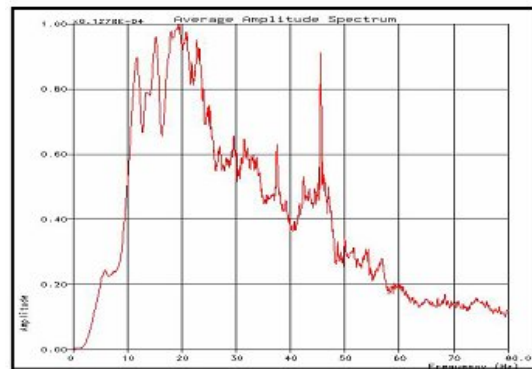


Fig-7: Amplitude spectrum before Noise Attenuation

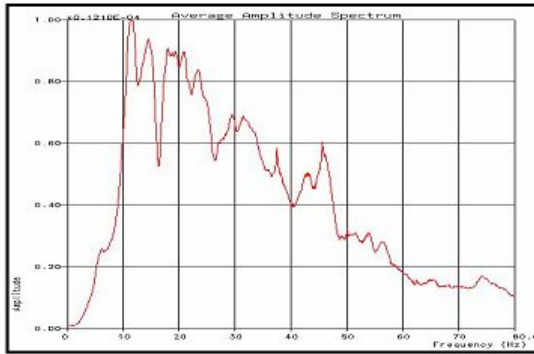


Fig-8: Amplitude spectrum after Noise Attenuation

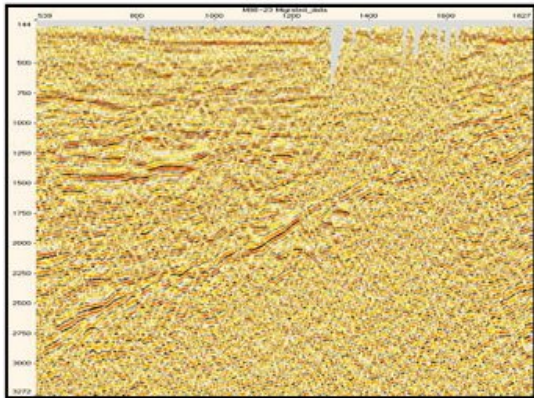


Fig-9: Old 2D section

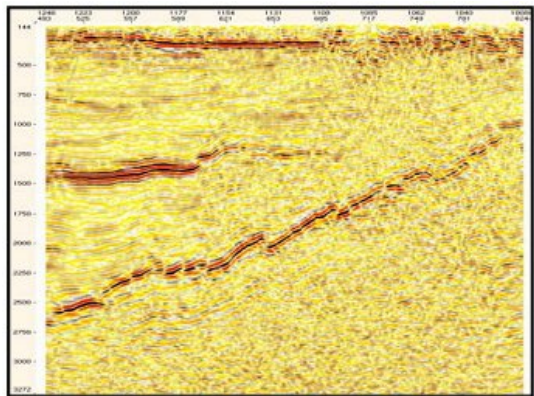


Fig-10 : Corresponding section from 3D volume

Improvement in Final Output (Stack)

Fig-6 shows the improvement in the brute stack section before and after noise attenuation.

Fig-9 & 10 shows the comparison of the old processed 2D section with a reconstructed line from the 3D volume along the same 2D line and shows the improvement in the stack section after applying this noise attenuation technique in the pre-stack stage. In the second figure, the basement configuration is clearly visible in comparison to the old section.

Conclusions

The method discussed here tackles high amplitude noise and other cultural noise in the gather while preserving the relative amplitude of the primary reflections, which is a pre-requisite for pre stack time & depth migration. This process enhances signal to noise ratio in the dataset, resulting good velocity estimation to produce quality output and reliable AVO studies. The noise attenuation in different stages shows an improvement over the other. The proper conditioning of gather in the pre-stack stage reveals an improvement in the final section. This present method is found to be superior as it saves time for the processor from manual editing and simultaneously avoids using statistically controlled auto editing method that fails to preserve the relative amplitudes. The application of this technique is multi ensemble domain & can handle almost all types of high amplitude noises, preserving the signal amplitude.

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