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# Application of Surface Consistent Amplitude Corrections as a Manual Editing Tool

Anil Kumar Semwal
*(Processing/ Pan India Consultants, Pvt. Ltd., India)*

***Abstract**: Manual editing serves as tool for removing strong noise bursts or spikes in the data. This requires huge effort when dealing with big volume of seismic data and attempting the human errors are inevitable at the same time. In the present work an effort is made on a field dataset to show that application of surface consistent amplitude corrections furnishes better results without human bias which is incumbent otherwise in manual editing.*
***Keywords**: Process time, surface consistent amplitude correction, manual editing, time-gain correction*

## I. Introduction

Ideally, one of the prerequisites for deconvolution of seismic data is that it should be free of noise. In this endeavor it goes through manual editing and various noise attenuation schemes. Manual editing is purely based on human perspective/ bias and leads to over omission of data in some space-time window while leaving noise spurts at another. Moreover, manual editing requires huge effort when a processing geophysicist has to deal with a 3D swath comprising millions of traces. Surface consistent amplitude correction, which is completely data driven, comes as a rescue at this point. The term surface-consistent implies that the time correction depends only on the surface location of the shot and receiver associated with the trace (Yilmaz, 2001).Surface consistent factors may be divided into source, receiver, offset, and subsurface components and these may be divided further into amplitude and phase (or time shift) factors. Correction of trace amplitudes using multiplication by a scale factor is similar to correction of phase distortions by a static shift, and both corrections enhance seismic data. Displays of surface consistent components for time and amplitude corrections provide an additional diagnostic for the geophysicist. (Taner & Koehler, 1981)

## II. Theory

Theory given here is the work from Taner & Koehler, 1981. In order to compute the surface consistent corrections within a reasonable degree of approximation and computational ease, we need to make the following assumptions:
(1) Factors due to effects at or near the surface are constant throughout the recording time; these include source response, source coupling, attenuation in the near surface layers, geophone sensitivity, and geophone coupling.
(2) Factors which remain time constant are also surface consistent. This means that the effects associated with a particular surface position remain constant regardless of the wave path. For example, source strength will affect all of the traces recorded from that source. Similarly, the geophone coupling effect remains the same for all traces recorded at a particular receiver station from various source positions.
(3) Common-depth-point (CDP) gathering is assumed to be valid. By this we mean that all traces at a particular CDP gather position contain essentially the same subsurface information.
(4) The corrections for spherical divergence, normal moveout, and field statics have been applied. We do this to eliminate most of the amplitude and arrival time corrections, so that within a time window all traces of a CDP gather satisfy the previous assumption.
Based on these assumptions, we can separate the surface consistent factors into the following four basic categories:
(1) $S_n(w)$ = Source response at surface position n. This refers also to the effects the near-surface imposes on the down going source wave front.
(2) $R_m(w)$ = Receiver response at surface position m. This refers also to the influence of the near-surface on the upward traveling reflected wave front.
(3) $C_k(w)$ = Subsurface response beneath surface position k. This represents the response for all traces with common midpoint k = (m + n)/2.
(4) $D_l(w)$ = Offset response at offset position 1, where 1 = m - n. This represents offset related responses such as cable response in the marine case, offset related spherical divergence effects, or the residual moveout effects.
Based on the above assumptions, we can show that a seismic trace, recorded at receiver position m with source position n, can be described in the frequency domain as the product of the four factors

$$F_{nm}(w) = S_n(w)R_m(w)C_k(w)D_l(w), \qquad (1)$$

where $k = (m + n)/2$ and $l = m - n$.

The objective here is to determine $C_k$ (w), the desired subsurface data. However, we can determine S(w), R(w), and D(w) responses only approximately and partially suppress their influence on the seismic data. We have one equation for each trace along a given line, and in most cases the number of unknowns (source, receiver, offset, and subsurface responses) is less than the number of equations. We therefore solve the set of equations in a least-mean-error-square manner. Equation (1) is in product form (convolutional form in the time domain), so it is inconvenient in its present form. If we take the natural logarithm of both sides, it becomes a linear equation:

$\ln F_{nm}(w) = \ln S_n(w) + \ln R_m(w) + \ln C_k(w) + \ln D_l(w).$ (2)

This can be simplified further by forming two separate equations, one by equating real parts, the other by equating imaginary parts:

$\ln F_{nm}(w) = \ln|F_{nm}(w)| + i\, \theta_{nm}(w),$ (3)

where the real part $\ln F_{nm}(w)$ is the logarithm of the amplitude spectrum of the trace, and the imaginary part $\theta_{nm}(w)$is the phase spectrum of the trace. So the equations obtained by equating real parts are linear equations in logs of amplitudes; those obtained by equating imaginary parts are linear equations in phase shifts, from which we derive time shifts. In practice, we solve these two sets of equations in two separate computations; the first is called true amplitude processing, and the second is automatic static computation.

## III. Method

First set of equations is used here for amplitude processing in CGG's system. A field dataset comprising a Land 2D line is used here. All the processing is carried out in CGG Veritas's Geocluster platform and it's proprietary solutions AMPSO/ GAINX & EDITE are made use of in this exercise for surface consistent amplitude correction computation & application. EDITE is also used for incorporating edit library generated by manual editing. AMPSO permits to calculate gain corrections for each shotpoint and each receiver of a 2D line in order to correct coupling conditions during transmission and reception of the signal. Correction coefficients are calculated according to the offset, and they are automatically stored either in a gain library as a permanent file or in a Dataset (gain type) of it's database.Traces whose average amplitude is greater than a user defined value times the average amplitude of the line are stored either in an editing library as a permanent file or in a Dataset (editing type) of it's database. The program can also perform independently of the preceding gain calculations, a trace equalization at a level M supplied by the user. Traces are weighted by a factor of M/AMP, AMP being the average of each trace. This allows the user to use equalized traces in the output buffer in the same job. Average calculations on the different traces are carried out inside a window defined by the user.

The program can also produce a plot of the amplitudes before and after correction. Traces must be ordered by CDP.Once gain & edit libraries have been computed, next phase is to incorporate these libraries using GAINX & EDITE modules, whereby, spike free and amplitude equalized gathers are generated.

## IV. Results And Discussion

In this exercise a Land 2D line is processed in three streams; (1) manual editing & application, computation & application of surface consistent amplitude correction (2) before and (3) after application of time-gain function. Gathers, stacks & amplitude spectra have been generated and component responses such as offset, CDP, source & receiver responses before and after the correction are plotted. A performance statistics is also tabulated for the three said streams. The navmerged data is manually edited in one stream while surface consistent amplitude corrections for the rest two are discussed as follows.

### 3.1 Gain Curves

The curves are drawn in the same order as they are computed. The pre correction offset curve is the smoothed curve of the averages for each offset class. The post correction offset curve is the non smoothed curve of the averages per offset class and weighted by offset gain coefficients which reside in the gain library.

The pre correction CDP curve is the curve of the averages per CDP after having corrected the offset effect only. Curve variations can be explained by source and receiver effects rather than by CDP effects. The post correction CDP curve is the preceding curve which has been smoothed. Pre correction shot point and receiver position curves are the mean amplitude curves after correcting offset and CDP effects. Post correction shot point and receiver curves are obtained after applying shot point corrections and receiver corrections found in gain coefficient library to the respective data.Component responses such as offset, CDP, source & receiver responses before and after the correction are shown in Figs. 1 & 2.

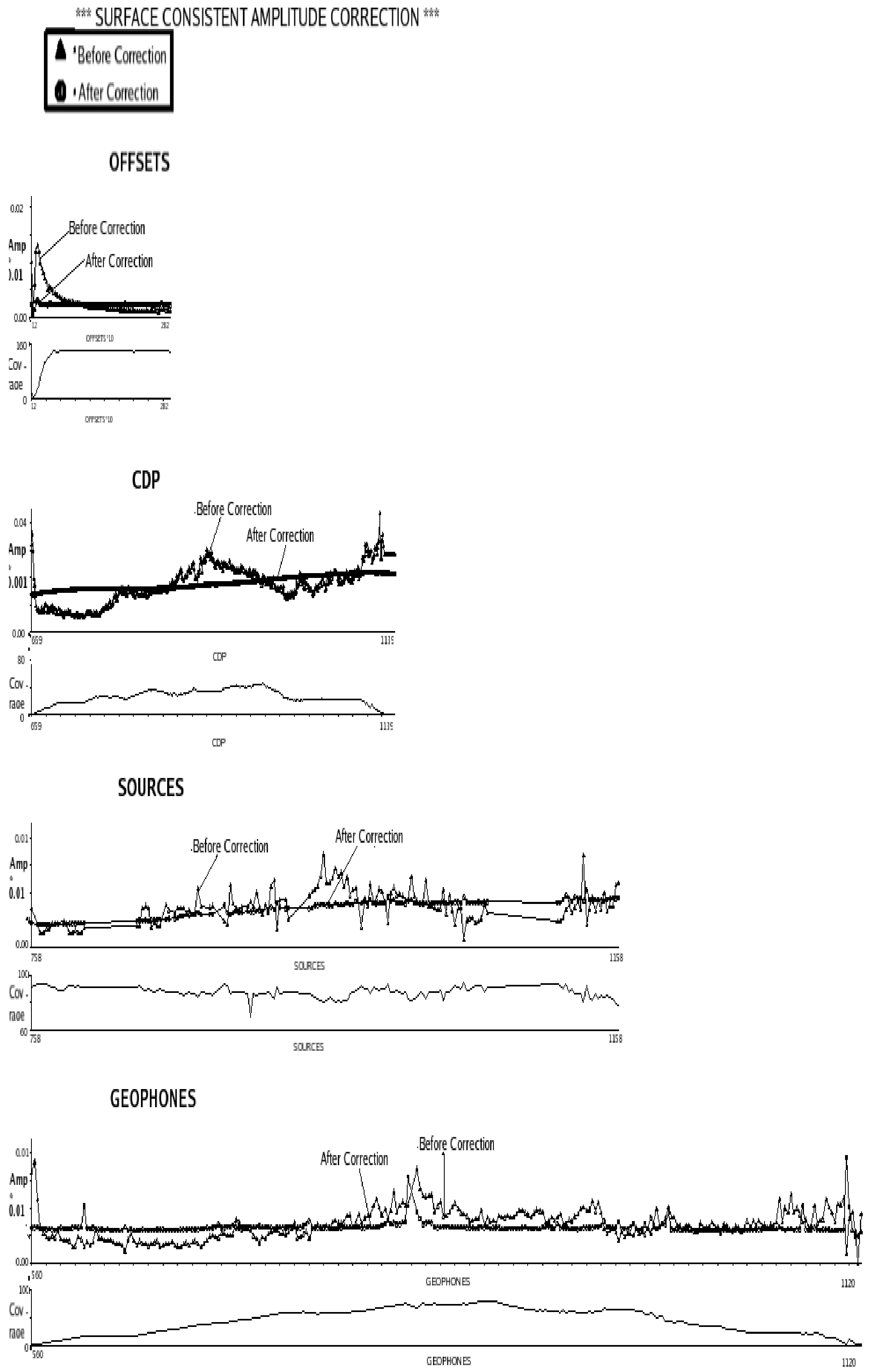


**Figure 1.** Surface Consistent Correction on data set for different components without time gain application i.e. Stream-2

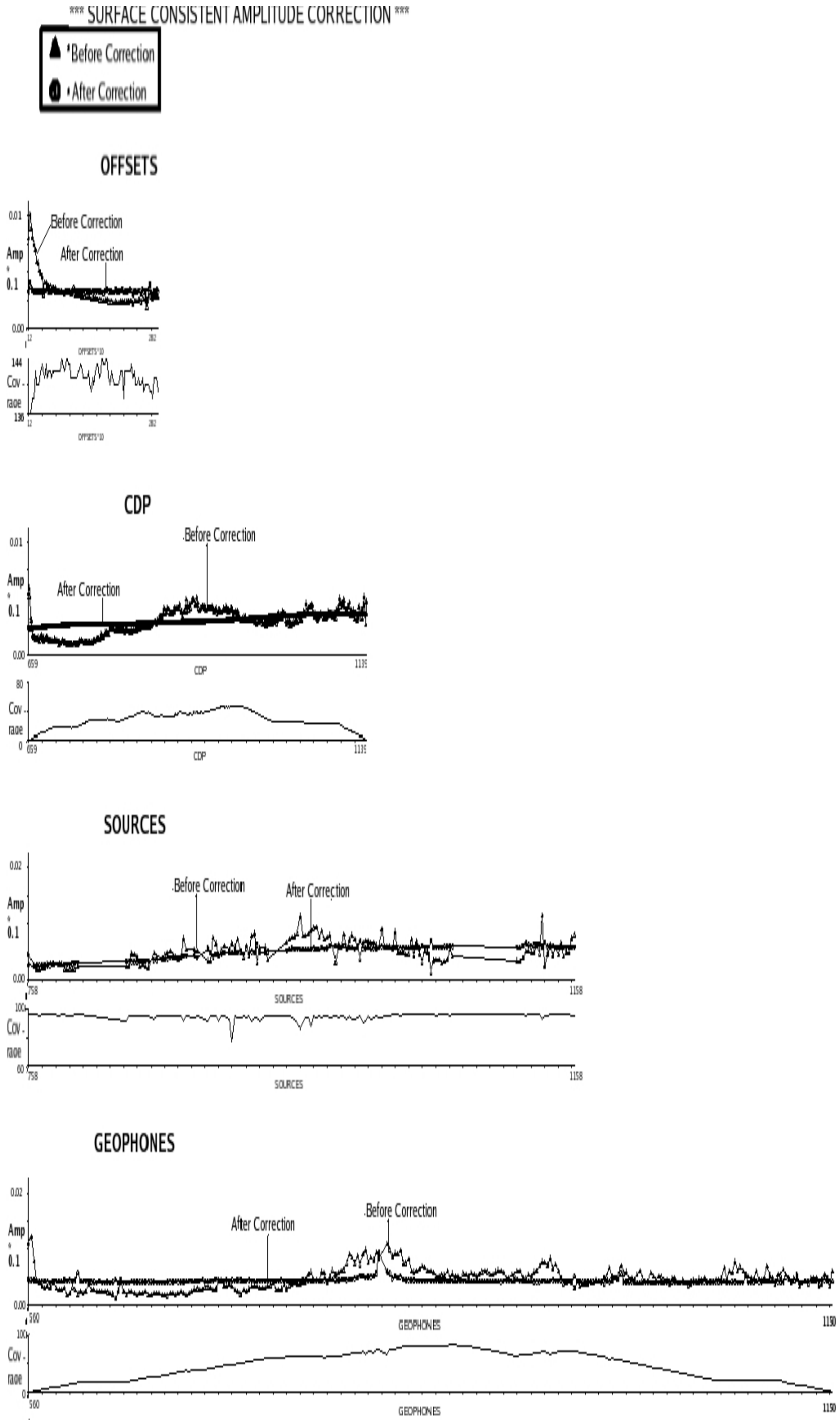


**Figure 2.** Surface Consistent Correction on data set for different components with time gain application i.e. Stream-3

### 3.2 Statistics

We, summarize the different parameters such as no. of traces rejected, no. of traces partially muted and time taken in each process in the following table. (Table-1)

**Table 1.** Performance statistics pertaining to different streams i.e. stream-1, 2 & 3

| Process □ / Parameters □ | **Stream-1: Creation of Trace Edit Library Using *Manual Editing on Time Gain Applied Data*** | **Stream-2: Creation of Gain & Edit Libraries using *SurfaceConsistent Ampliude Correction On Data Without Time Gain Application*** | **Stream-3: Creation of Gain & Edit Libraries using *Surface Consistent Ampliude Correction On Time Gain Corrected Data*** |
|---|---|---|---|
| **Total No. Of Traces** | 14016 | 14016 | 14016 |
| **Actual Total No. Of Traces Taken For Processing After Reconciliation** | 13665 | 13665 | 13665 |
| **No. Of Offset Classes** | 96 | 96 | 96 |
| **No. Of Shots Rejected** | 0 | 0 | 0 |
| **No. Of Traces Partially Muted** | 329 | 0 | 0 |
| **No. Of Traces Rejected** | **521** | **1068** | **100** |
| **Average Amplitude Of The Line** | | **0.000018** | **0.000266** |
| **Process Execution Time** | **~3 Hr.** | **22.72 Sec.** | **23.28 Sec.** |

Maximum no. of traces altogether rejected or partially muted descends in the order from stream-2, stream-1 to stream-3 processes. Stream-1 is purely a manual editing and a human bias is inevitable. In surface consistent amplitude correction computation, average amplitude of the line is an important control parameter for the trace rejection & gain library computation. This parameter in the stream-3 is roughly 15 times larger than the stream-1, i.e. stream-3 has a higher threshold for trace rejection than stream-2, and so, the trace rejection count in stream-3 is less than one-tenth of stream-2. From the point of view of lesser trace rejection or data loss, stream-3 best befits the requirement, next to it falls stream-1 followed by stream-2.Moreover, manual editing (i.e. creating edit library) in stream-1 for this small land 2D data set is roughly 3 hours while stream-2 & stream-3 processes' execution time (including edit & gain coefficient library computation) is of the order of some tens of seconds. Process execution time is another concern and stream-2 & stream-3 processes can be designated as far more cheaper than stream-1 process.

### 3.3 Gathers, Stacks & Amplitude Spectra

Two sample shot gathers (shot point 766 & 920) for the three streams are shown in Figs. 3 & 4. In Fig. 3, stream-1 (manual editing) processed data still shows left out prominent spikes, which are absent at all in stream-2 & stream-3. Continuity of events & crispness is most evident in stream-3, followed by stream-2 & stream-1. Trace rejection is stronger in stream-1 (3 traces) & stream-2 (3 traces) and least in stream-3 (1 trace).
Fig. 4 is an example of spike free gather processed on the said streams, depicts, that event continuity & crispness is maximum in stream-3 followed by stream-2 & stream-1. Moreover, trace rejection is maximum for stream-2 (6 traces) followed by stream-1 (5 traces) and no traces are rejected in stream-3 data.

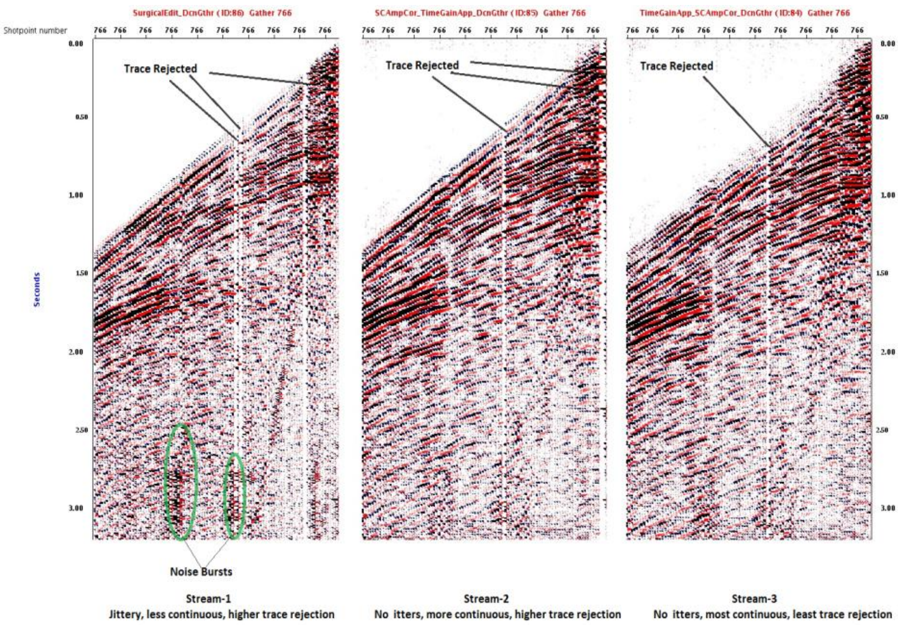


**Figure3.** Shot Gather 766 processed on stream-1, 2 & 3

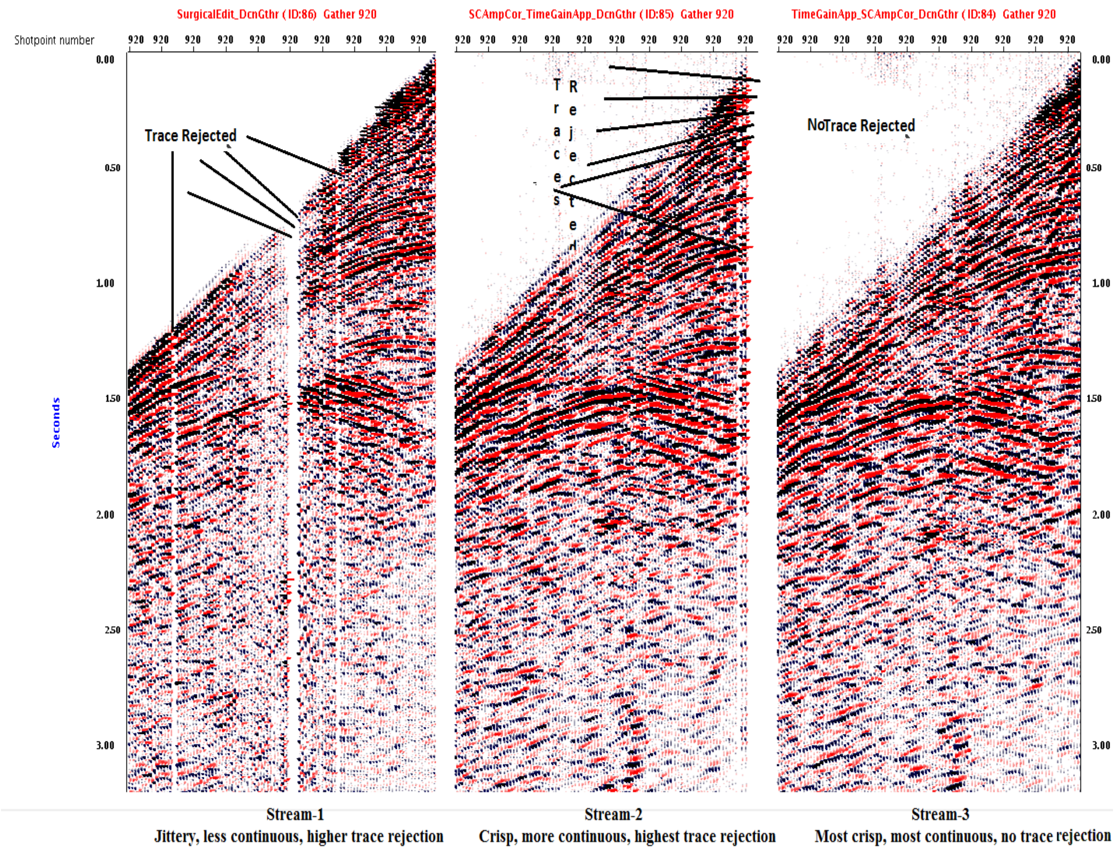


**Figure4.** Shot Gather 920 processed on stream-1, 2 & 3

Above gathers are stacked (Fig. 5) using same velocity field for different streams and are compiled below with respective amplitude spectra (Fig. 6).

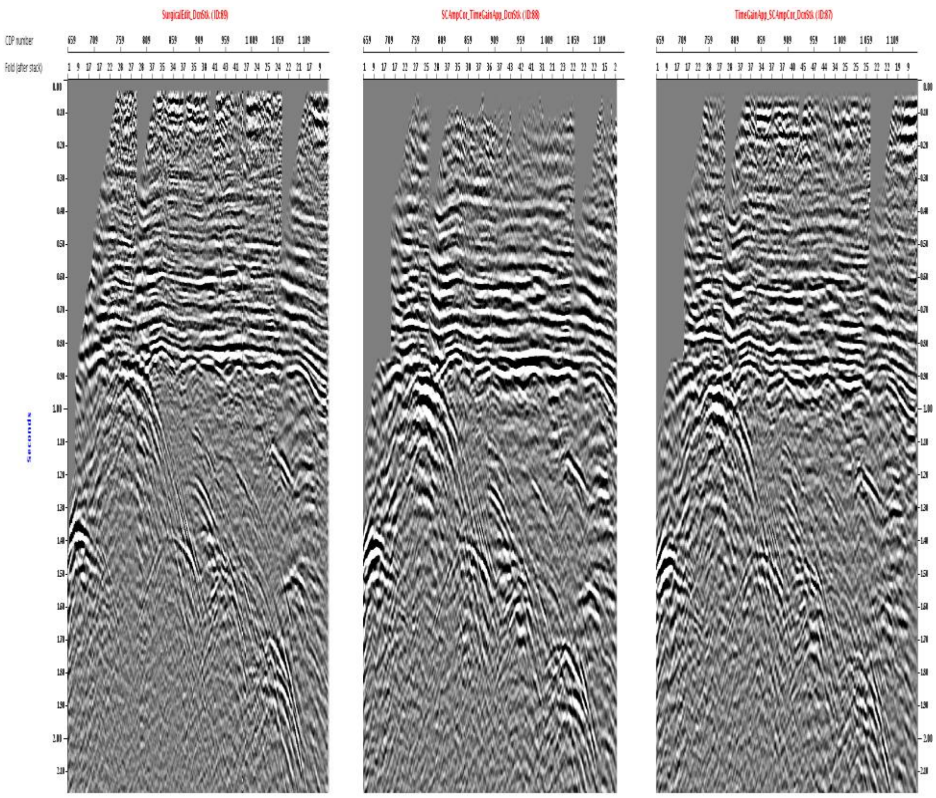

**Figure5.** Stack section generated for stream-1, 2 & 3

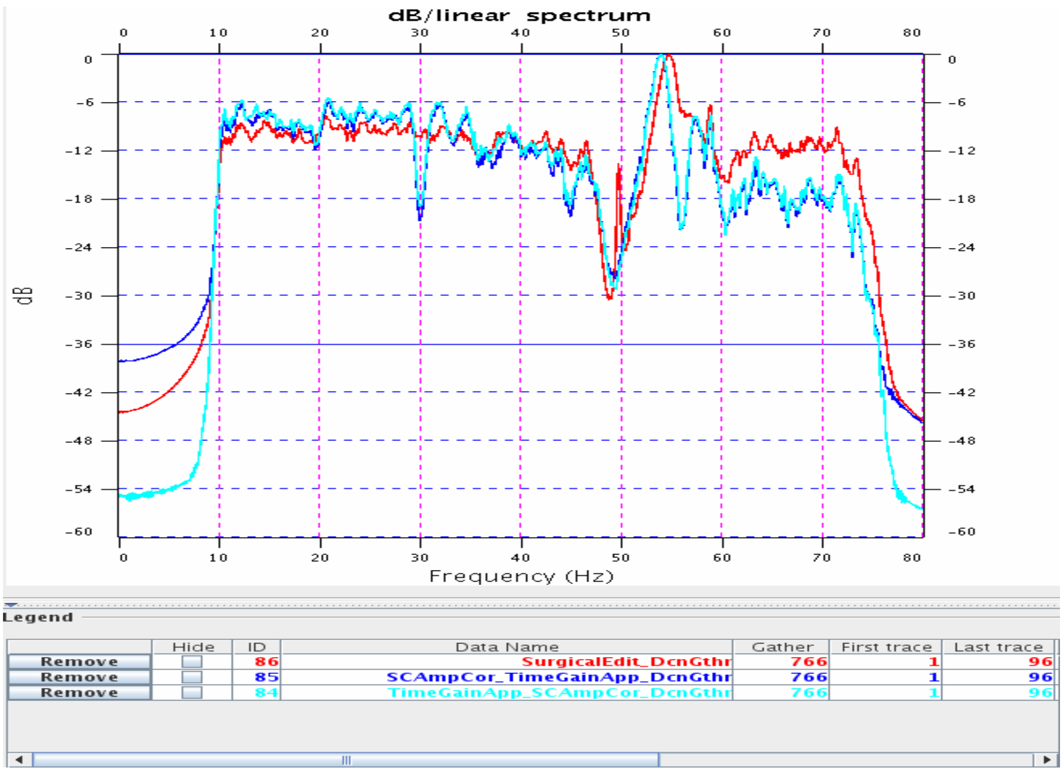


**Figure6.** Amplitude Spectra of data processed on stream-1, 2 & 3

Maximum continuity is achieved in stream-3 stack followed by stream-1 & stream-2., which is due to variability in degree of trace rejection & effective amplitude correction incorporated therein. (Fig. 5) Although, stream-2 & stream-3 follow the same correction computation technique, yet, there is a difference that input data is time-gain corrected for stream-3 while input for stream-2 is not corrected for time-gain. Application of time-gain correction strengthens average amplitude of the line by more than a factor of 10 (refer table-1), so trace population becomes high, thereby replenishes sufficient data variance for a better statistical estimation in computing amplitude corrections and results in lesser trace rejection and consistent amplitudes. Stream-2 stack is worst effected in the shallow horizons for the very reason that sample amplitudes without time-gain application in shallow times are very high (higher than the threshold, i.e. some multiple of average amplitude of the line which is weak in this case) and thus either weighted weakly or get muted. Fig. 6 depicts that within frequency band 10-40 Hz stream-2 & stream-3 data achieve higher amplitudes than that of stream-1. Further dissecting this also reveals that in this band stream-3 frequency components are slightly stronger than stream-2 amplitudes.

## V. Conclusion

It is evident from the above gathers & stacks that application of surface consistent amplitude correction furnishes better results in terms of event continuity, sharpness & process execution time in comparison with manual editing. Moreover, shallow times are best illuminated using surface consistent amplitude correction provided time-gain corrections are applied to input data. Other than human time & effort, manual editing involves human bias and in turn incorporated errors, whereas, application of surface consistent amplitude correction is purely a data driven technique thereby furnishes unbiased results. In a large data set scenario, such as, a 3D swath, manual editing becomes a huge task and to circumvent this problem, application of surface consistent amplitude correction may be seen as an option.

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## References

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