

Procedures for Correcting Seasonal Variations

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ABSTRACT

The standard procedures used in New Zealand to correct for seasonal variations are the MSSC and ESC for within year and between year respectively. These procedures have generally worked well; however, the procedures do assume that there is a one to one relationship for the correction factor across the range of skid resistance values. This assumption has recently been investigated and it was found that at the extremes of the skid resistance range significant errors could be introduced in the corrected values using a simple correction factor. An alternative approach using regression, which proportionately corrects the data rather than using a single factor, has been investigated. Approximately 100km of highway which contained 2 seasonal control sites was used for the investigation. This length of highway was surveyed four times in October, November, January and February. The results from these surveys were used to compare the correction procedures. It was found that the results from the regression procedure, when correcting the within year seasonal variation, were superior to those produced by the single factor procedure. No analysis has been carried out using the regression procedure for correcting for the between year seasonal variation, but a suggested procedure has been described.

1.0 INTRODUCTION

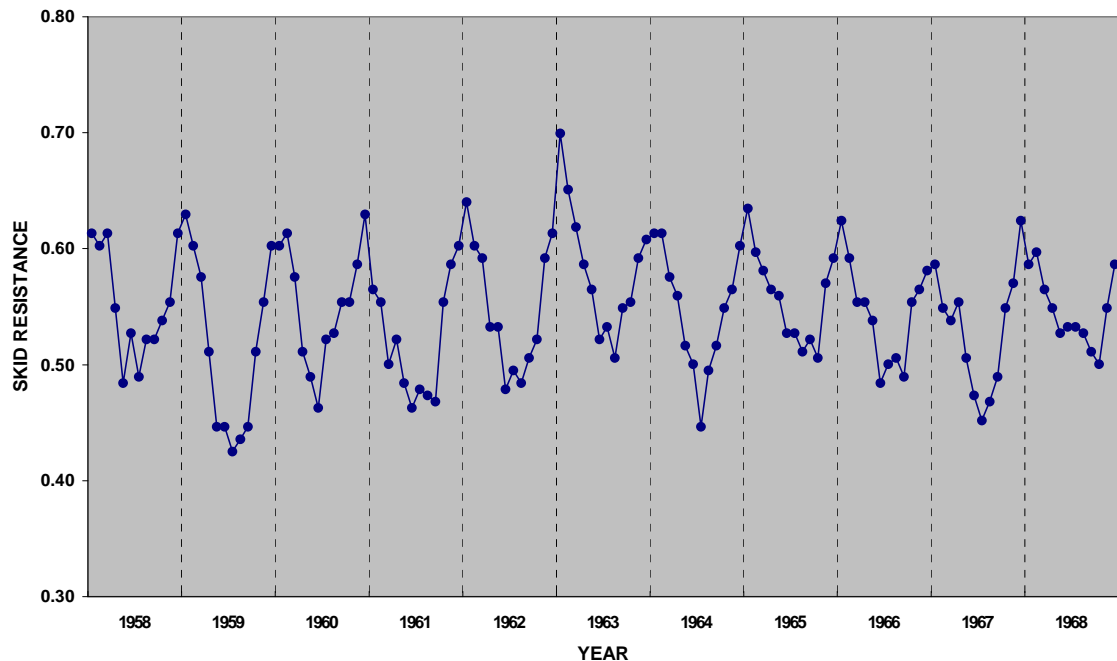
It is known that the skid resistance available at the road surface under wet conditions will vary throughout the year with the lowest values occurring towards the end of the summer and the highest values during the winter.

Tests carried out at a series of trial sections between 1988 and 1992 in New Zealand showed very pronounced seasonal changes in skid resistance, with minimum summer values being approximately 30% lower than peak winter values¹.

A study in Australia showed that seasonal variation was evident in all states except Queensland². This study found that during the wet season the skid resistance of road surfaces were higher than during dry periods. In the United Kingdom, studies have shown that the variation is due mainly to seasonal changes in the grading of the abrasive material lying on the road or embedded in vehicle tyres³. Natural weathering of the aggregate particles due to prolonged wetting and frost action also contributes to the improvement in microtexture during the winter months⁴.

Figure 1 shows an example of the extent of variation in skid resistance due to the season. These measurements are from a British study⁵ in which monthly skid resistance values were recorded over an 11-year period at a group of sites where the long-term skid resistance level was constant.

Figure 1 Result of Monthly Skid Testing Over an 11 Year Period



To minimise this seasonal effect, testing is limited to the summer months each year. Nevertheless, this within year, or more correctly within summer, variation means that parts of the highway tested at different times during the summer can record different levels of wet road skid resistance even if, had they been tested on the same day, the values would be identical.

The within year variation could therefore lead to an inefficient use of maintenance resources because those sections tested towards the end of the summer would be more likely to be identified for treatment than those tested early or late in the

summer. It would also be impossible to obtain reliable trends from one year to the next.

Highway authorities can use a number of methods to correct for these seasonal effects. The simplest approach to allow for within year effects is to survey the network three or more times at reasonably spaced intervals during the test season, and average the results, but this would prove to be prohibitively expensive. A reasonable alternative is to establish control sites and test these three times a year. The mean of the 3 readings is known as the Mean Summer SCRIM Coefficients (MSSC). Several control sites are normally used for each area and the MSSC is the average of all the sites. The average SC values obtained on all the control sites for the area obtained during the main survey period is divided into the MSSC and the result is a single factor correction value that can be applied to all 10m SC values in the area to give the MSSC values.

The recent weather patterns have provided additional complication since it is apparent that there is greater year on year variation occurring, although from Figure 1 it can be seen that there has always been some variation between years. There is therefore also a need to correct for the between year variations. The between year variations can be corrected using the control sites but by keeping a time series over a number of years to produce an equilibrium SCRIM Coefficient (ESC) values.

2.0 ALTERNATIVE PROCEDURE FOR SEASONALLY CORRECTING SCRIM RESULTS

The single factor procedures to produce the MSSC and ESC values have generally worked well and have produced reasonably consistent results from year to year. However, the procedures do assume that there is a one to one relationship for the correction factor across the range of skid resistance values measured within and between each year. This assumption has recently been investigated and it was found that at the extremes of the skid resistance range significant errors could be introduced in the corrected values using a simple correction factor. An alternative approach using regression has been investigated. In this paper, the regression procedure is described and compared with the current procedures.

2.1 SITE DETAILS

The road used for the study was a state highway in the middle of the North Island. This road encompassed 2 seasonal control sites. The road was tested four times in both the increasing and decreasing directions on the following dates, 19th October 2003, 13th November 2003, 3rd January 2004 and 13th February 2004.

During the January survey, the temperature was very high and there were significant lengths of bleeding and tracking along the route. In order to avoid contamination the operator raised the SCRIM tyres over the lengths where bleeding and tracking were evident. The sections where the data was aborted due to the tyres being lifted was removed from each of the surveys and not included in the analysis. This resulted in 5.24km of data being removed from the increasing direction and 1.9km of data removed from the decreasing direction. Also, any SCRIM data for road lengths that have been resurfaced between October and March were removed. The length of the study road after the sections were removed was 98.7km.

2.2 RESULTS OF THE INVESTIGATION

The average SCRIM coefficients for each Reference Station length were calculated for both increasing and Decreasing Directions and are shown in Tables 1 and 2. This gave four RS lengths in two directions for the comparison between the single factor procedure and regression procedure.

Tables 1 and 2 show four sections of the state highway numbered 1 to 4, these values have been corrected for speed and temperature but not seasonally corrected.

Table 1: Average SCRIM Coefficients Increasing

RS	Oct	Nov	Jan	Feb
1	0.50	0.47	0.55	0.46
2	0.51	0.46	0.56	0.46
3	0.49	0.45	0.56	0.47
4	0.49	0.47	0.56	0.45

Table 2: Average SCRIM Coefficients Decreasing

RS	Oct	Nov	Jan	Feb
1	0.48	0.47	0.44	0.47
2	0.50	0.45	0.42	0.49
3	0.50	0.46	0.46	0.50
4	0.47	0.43	0.46	0.47

For the increasing direction it can be seen that the lowest SCRIM values were obtained in November when the main survey of the region was carried out and surprisingly the highest SCRIM values were measured in January, even though there was significant bleeding at this time. The results for the decreasing direction are comparable for each month except January which is producing the lowest average SC except for section 4.

2.3 PROCEDURE FOR CORRECTING WITHIN YEAR SEASONAL VARIATIONS

2.3.1 Single Factor Procedure

The single factor correction values have been calculated using the two control sites and are shown in Table 3. These factors are obtained from 2*1km lengths and are applied to each individual 10m SC value for the whole study length.

Table 3 Single Factor Correction Factors

Month	Single Factor Correction Values
October	0.98
November	1.05
January	0.90
February	1.09

The SCRIM data is corrected by a single factor to produce a seasonally corrected value and will tend to adjust values closer to the mean of the data more appropriately than the values at the extremes. This can lead to significant errors if there are a large number of extreme values

2.3.2 Regression Procedure

The use of linear regression proportionately corrects each of the 10m SC values rather than applying a single factor, this should reduce any the errors at the extremes of the data.

For the regression procedure, the individual 10m SC values for the 2 control sites normally used for seasonal correction for each month are plotted against the mean 10m SC values for all four months. The resulting graphs are shown in Figures 2 to 5.

Figure 2. Regression of October against the Mean for All Months

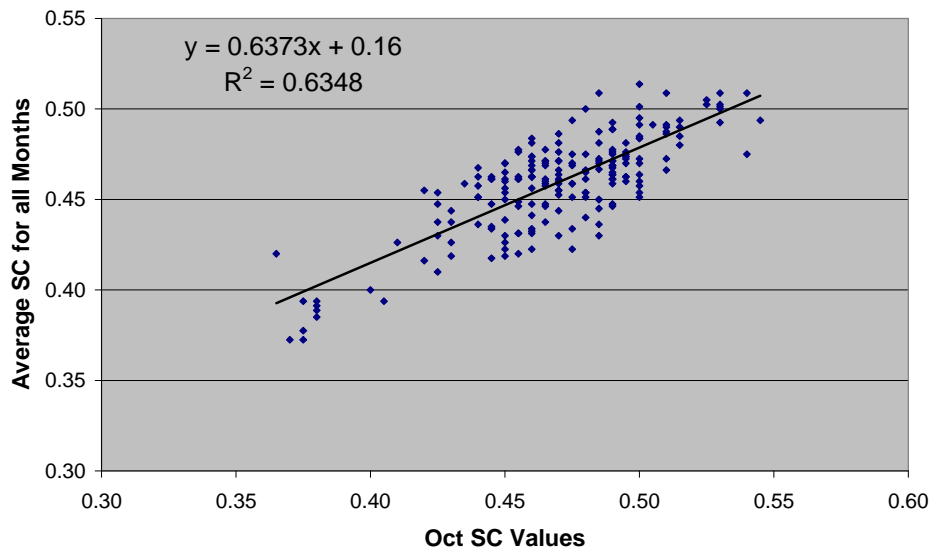


Figure 3. Regression of November against the Mean for All Months

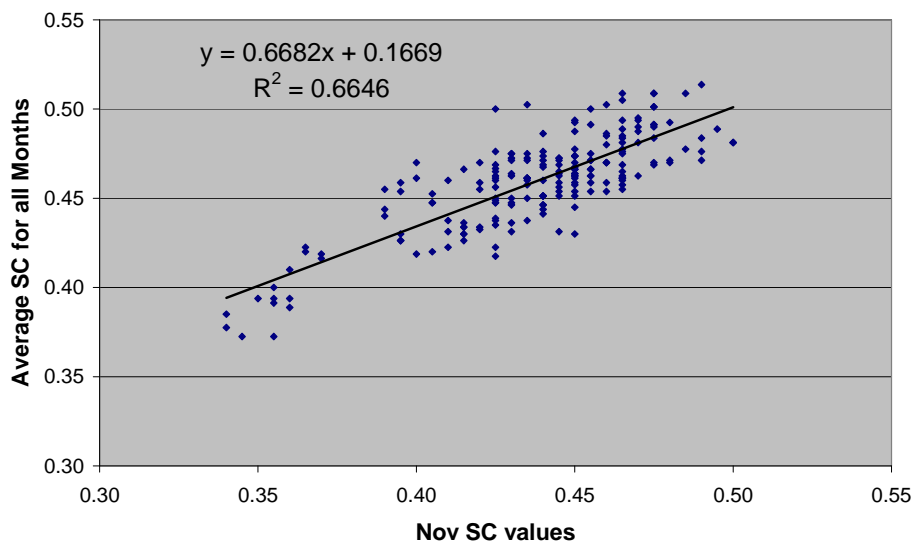


Figure 4. Regression of January against the Mean for All Months

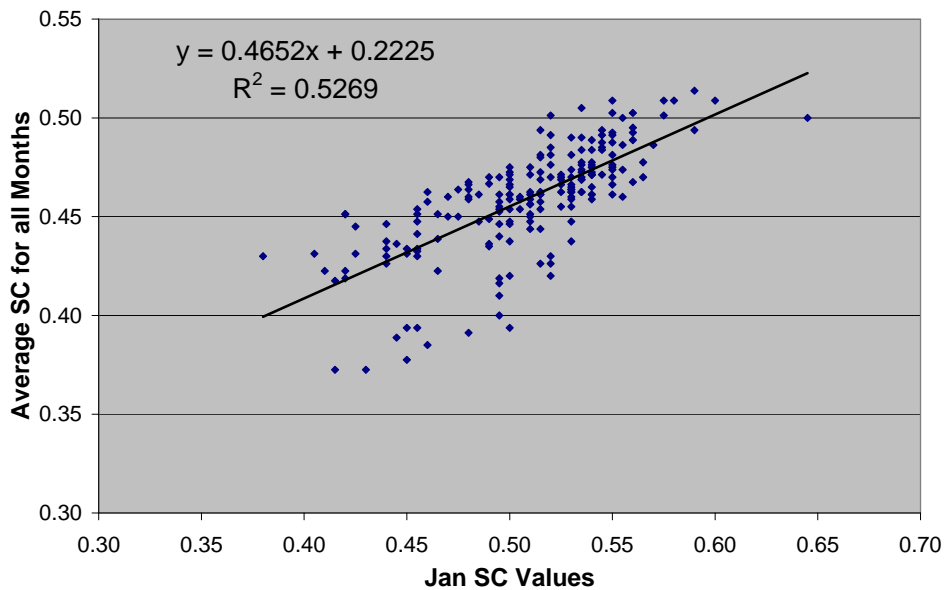
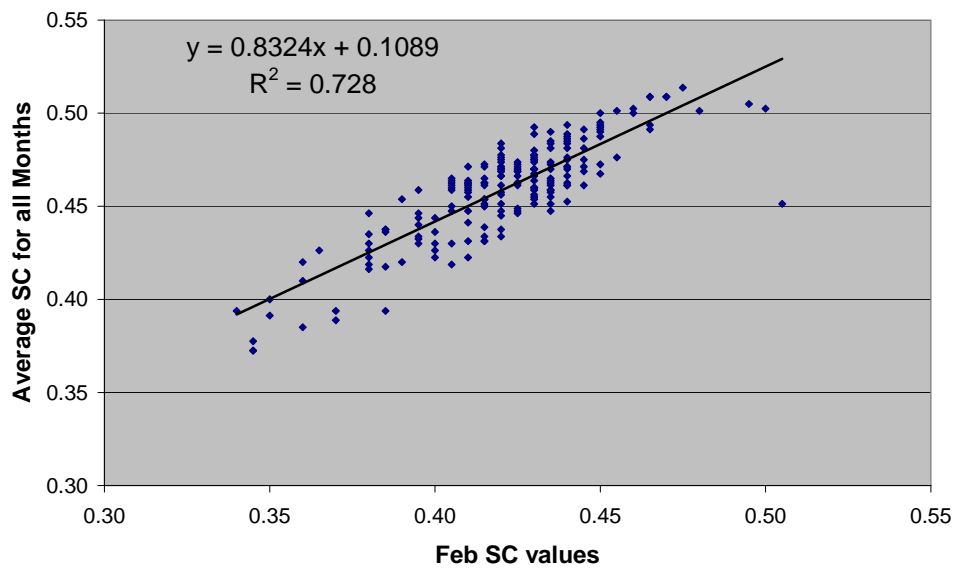


Figure 5. Regression of February against the Mean for All Months



As seen a linear trend line has been drawn through each set of data. An equation of the line is produced for each month as shown in each Figure, also shown is the coefficient of variation (r^2). The r^2 ranges from 0.53 for January to 0.73 for February. As discussed the wheel was lifted to avoid areas that were flushed and bleeding in the high temperatures during the January survey. However, even where there is no visible distress the surface the may be affected by the high temperatures because of a reduction in the adhesive strength of the binder. This may leave the surface stone layer susceptible to movement under the SCRIM test tyres producing variable results and may account for the reduced correlation in the January month.

The appropriate regression equation is applied to each 10m SC for the appropriate month for the whole study length to adjust for within year seasonal variation.

2.3.3 Comparison Between the Single Factor and Regression Procedure

The uncorrected 10m SC values for the increasing and decreasing direction are shown in Figure 6 and 7.

Figure 6 **Uncorrected Data Increasing Direction**

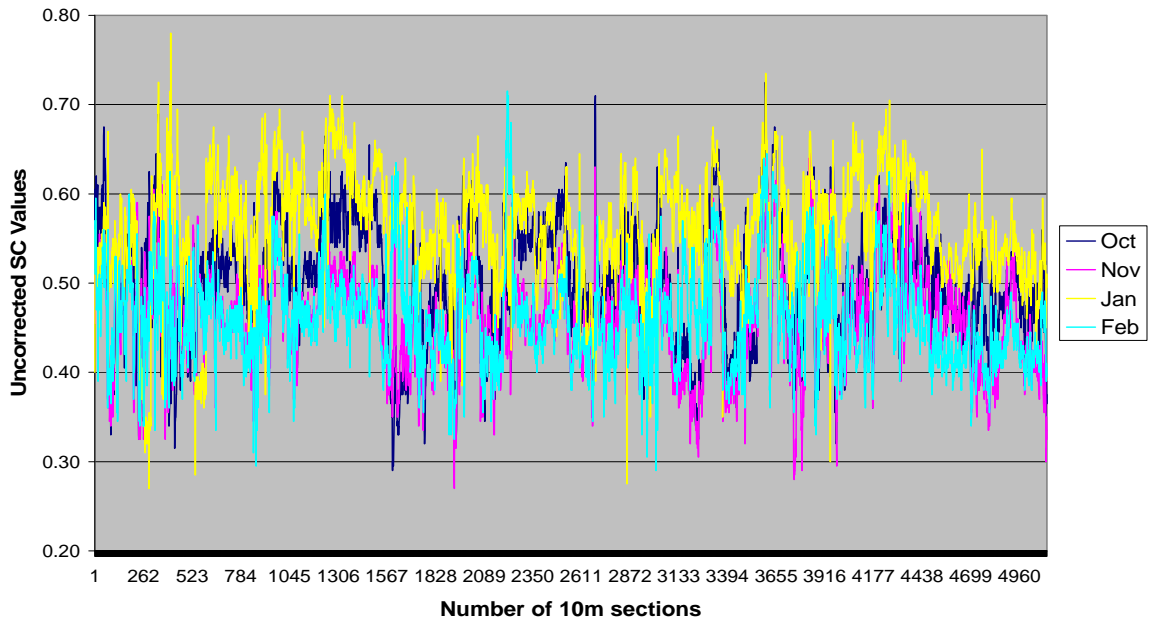
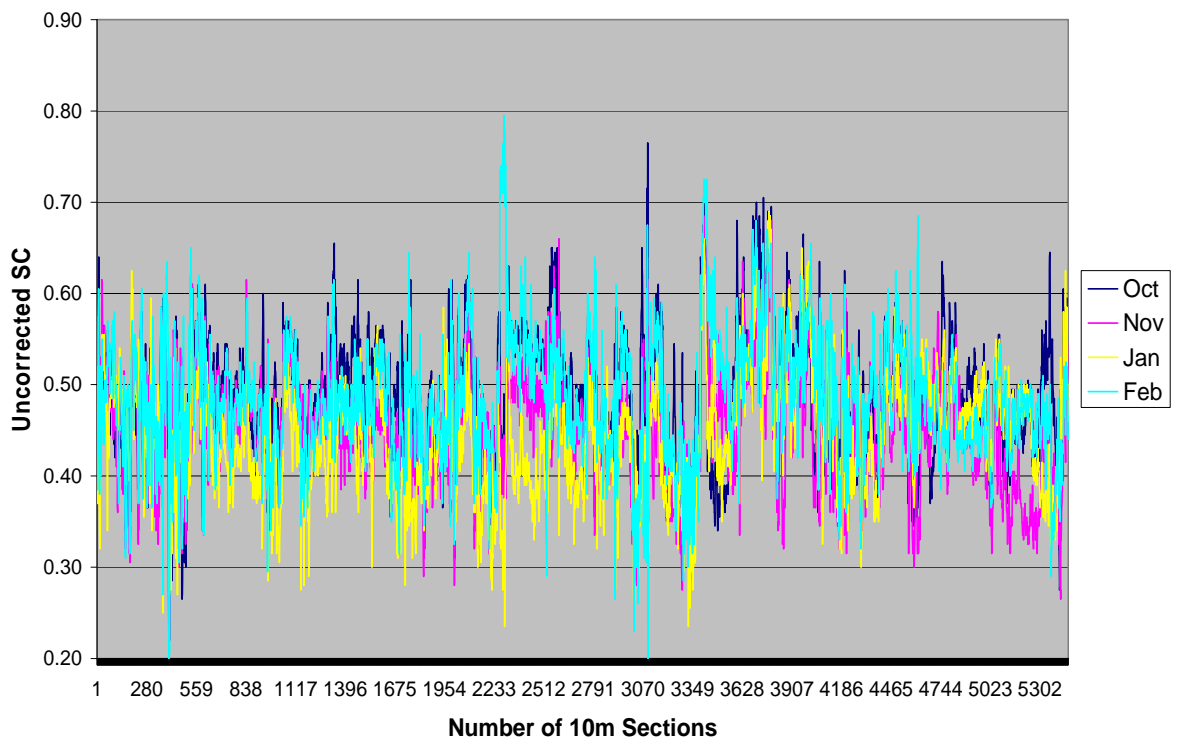


Figure 7 **Uncorrected Data Decreasing Direction**



As would be expected there are significant differences between the months. This is shown particularly in Figure 6 for January shown in yellow and February shown in light blue. The results for the same data after correction by the single factor procedure are shown in Figures 8 and 9.

Figure 8. Individual 10m SC for Increasing Direction Corrected by the single factor procedure

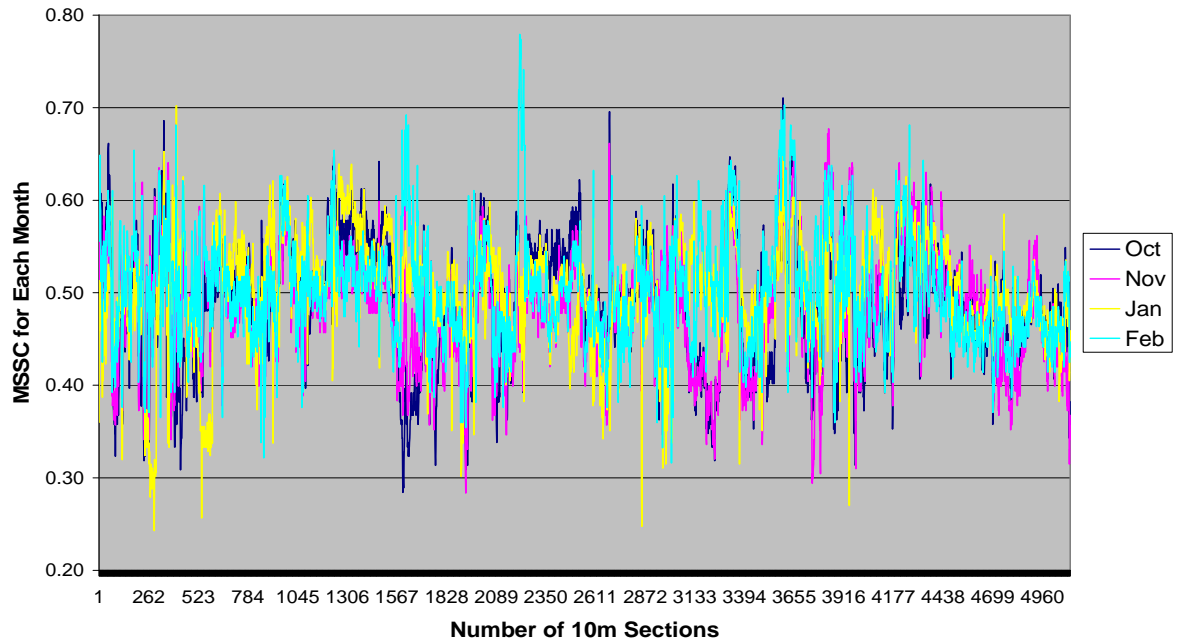
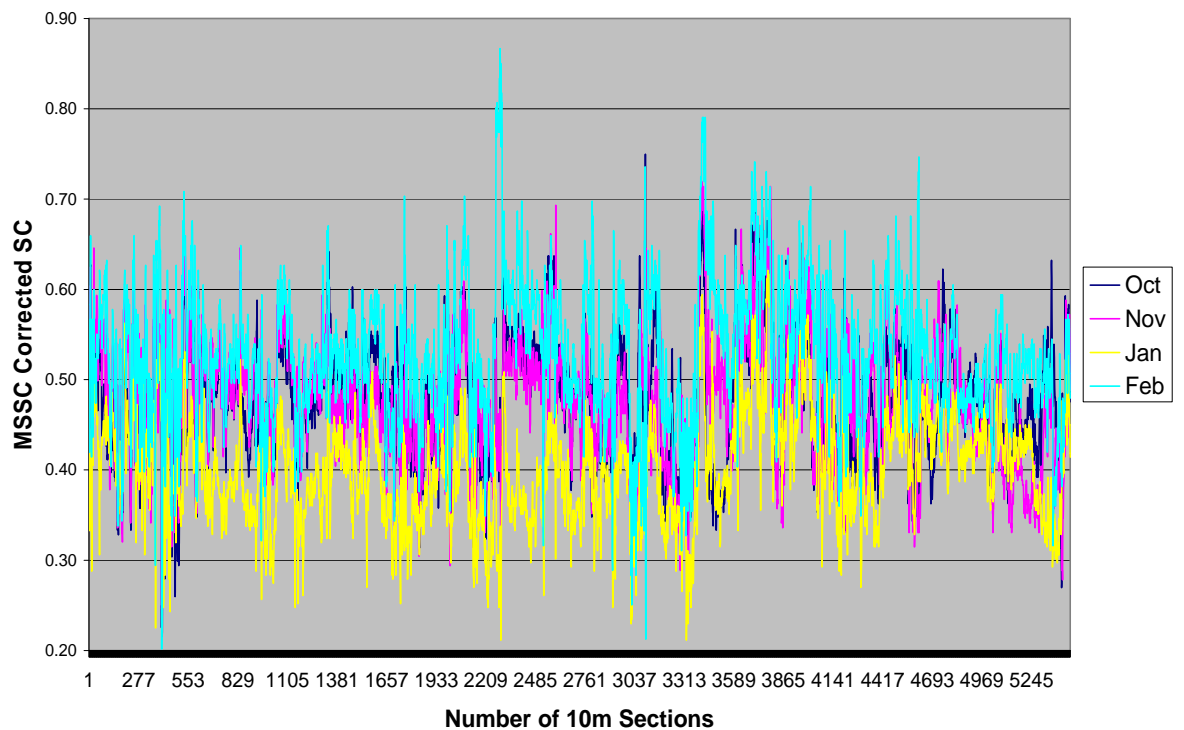


Figure 9. Individual 10m SC for Decreasing Direction Corrected by the Single Factor Procedure



The single factor corrected data in Figure 8 has reduced the differences between the SC values as can be clearly seen for January and February in the increasing direction. For the decreasing direction in Figure 9 the single factor corrected data has decreased the difference for all months except January which as discussed previously had a higher than average SC values for the increasing direction and lower than average in the decreasing direction.

The corrected SC values using the regression procedure is shown in Figure 10 and 11. For the increasing direction, it can be seen that the extreme values have been reduced and each month virtually sits on top of each other. The results for the decreasing direction have again reduced the number of values that significantly vary from the each other this is because the regression equations proportionately adjust each 10m value rather than adjust by a fixed value.

Figure 10. Individual 10m SC for Increasing Direction Corrected by Regression

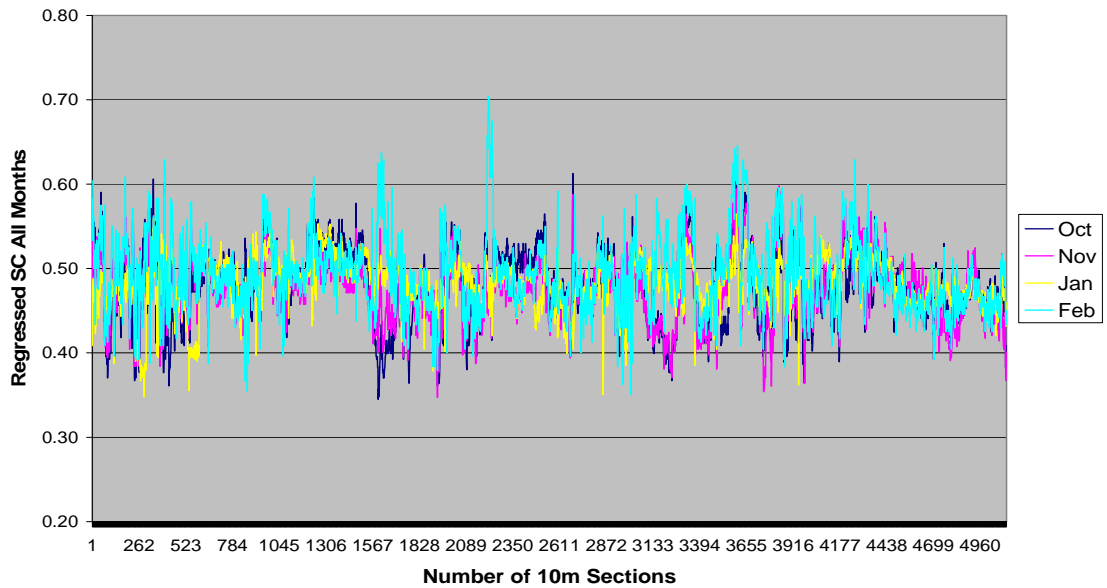
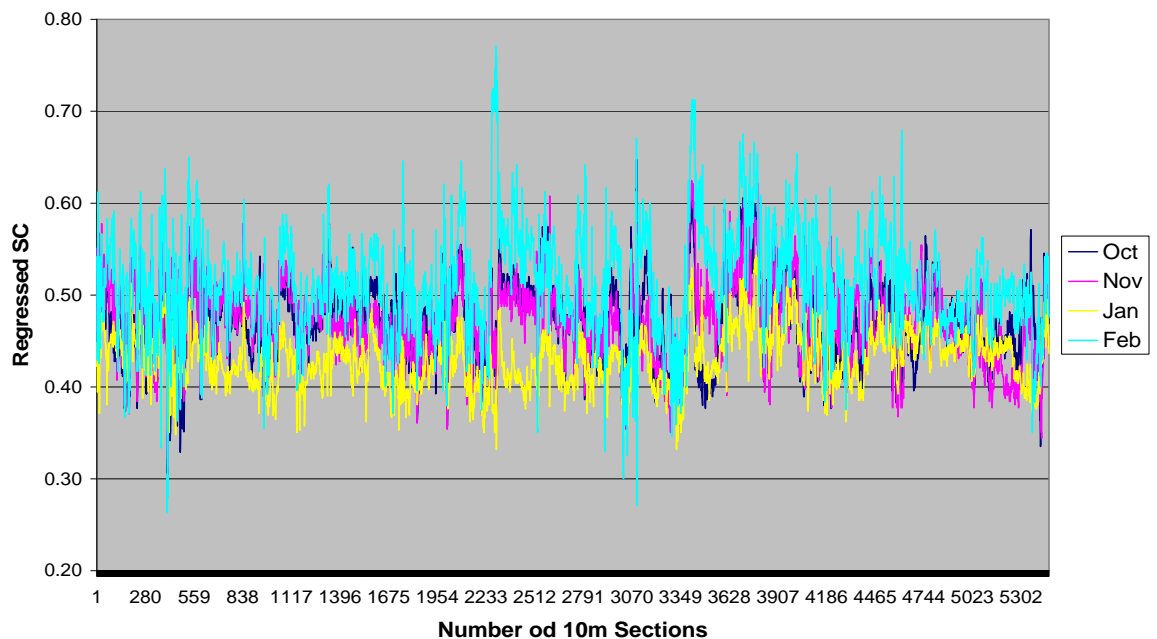


Figure 11. Individual 10m SC for Decreasing Direction Corrected by Regression



A reduction in the extreme values is important since this will lead to a reduction in the low values. This can be seen by the number of values below say 0.35 in Figures 10 and 11 as compared to Figures 6, 7, 8, and 9. Thus, from the data used in this study the regression procedure will result in less values being below the investigatory level and can ultimately reduce the number of unwarranted site investigations.

The reduction in extreme values can be shown more clearly if, for example a small number of SC values are corrected using the single factor procedure and regression procedure as shown in Table 4. In this case, the correction factors are from the February survey but any of the survey factors would suffice to illustrate the idea.

Table 4 Example of Correcting SC Values using Single Factor and Regression

Uncorrected SC Value	Corrected by Single Factor	Corrected by Regression
0.7	0.76	0.69
0.6	0.65	0.61
0.5	0.55	0.52
0.4	0.44	0.44
0.3	0.33	0.36
0.2	0.22	0.28

As can be seen the single factor procedure corrects the data by a fixed amount (in this case using the multiplier 1.09) whereas, the regression procedure using the equation $y = 0.832x + 0.1089$ which allows the adjustment to be tailored for each of the SC values. As seen for high SC values, 0.7 and above, the adjustment is a reduction whereas for lower values an increase is applied. The single factor procedure either adjusts by applying an increase or a decrease to a data set but not both.

2.3.4 Comparing the Data against the Mean

If the correction procedure is successful, the adjusted values should be very close to each other regardless of the month the survey was carried out. To test this for the single factor procedure and the regression procedure the mean for the corrected 10m value were calculated for all four months for each procedure. The corrected 10m value for each month was subtracted from the mean and the resulting data plotted as histograms shown in Figures 12 to 19. If the correction was perfect all the data would be in the 0 band i.e. no difference between the corrected individual values and the mean of the values.

Figure 12. October Values Subtracted from the Mean - Increasing Direction

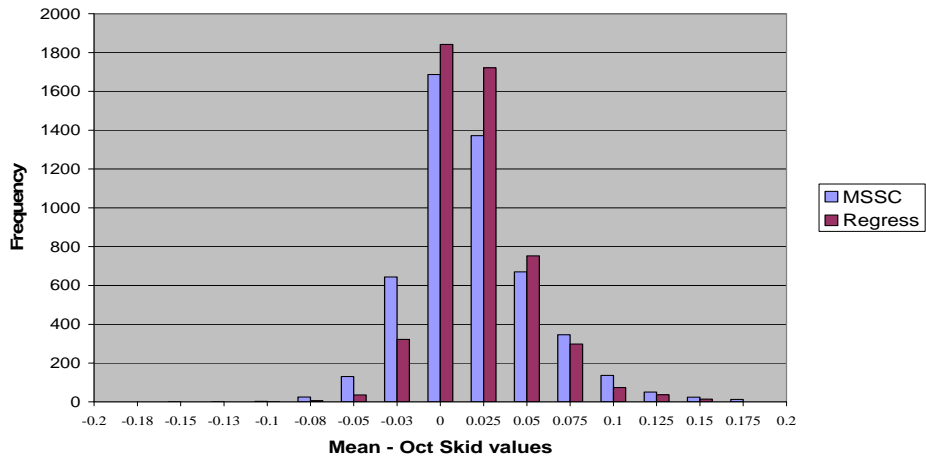


Figure 13 November Values Subtracted from the Mean - Increasing Direction

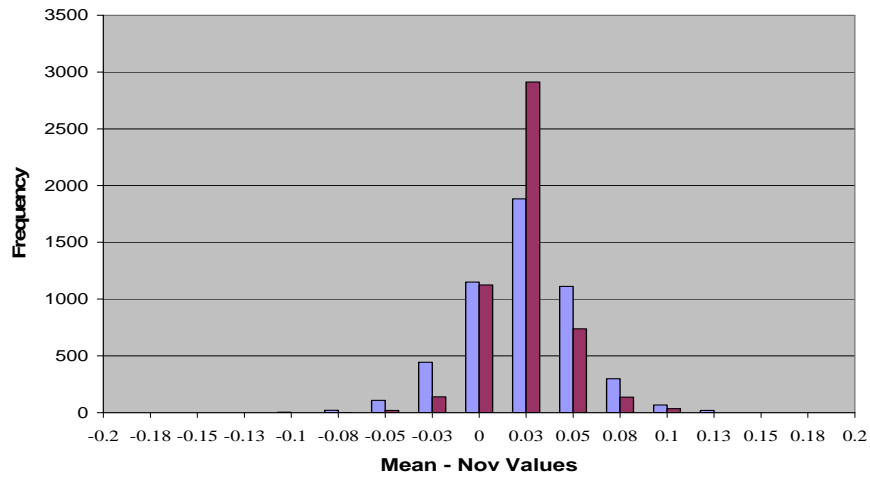


Figure 14 January Values Subtracted from the Mean - Increasing Direction

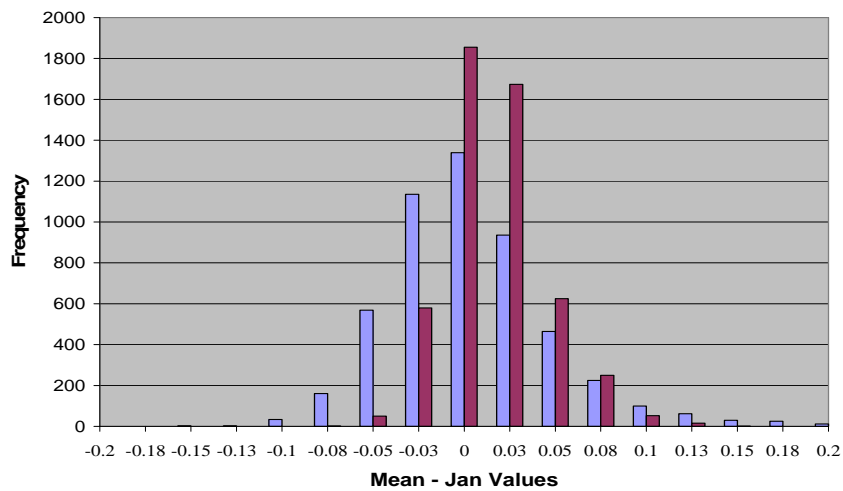
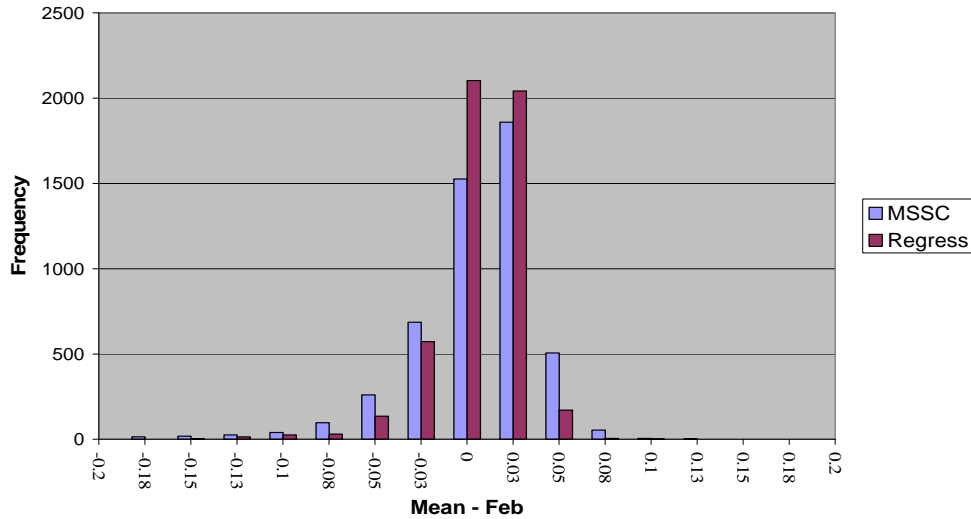


Figure 15 February Values Subtracted from the Mean - Increasing Direction



As can be seen from Figures 12 to 15 the SC values for the increasing direction that have been corrected using the regression procedure in red lay closer to zero band than the single factor corrected values in blue.

Figure 16 October Values Subtracted from the Mean - Decreasing Direction

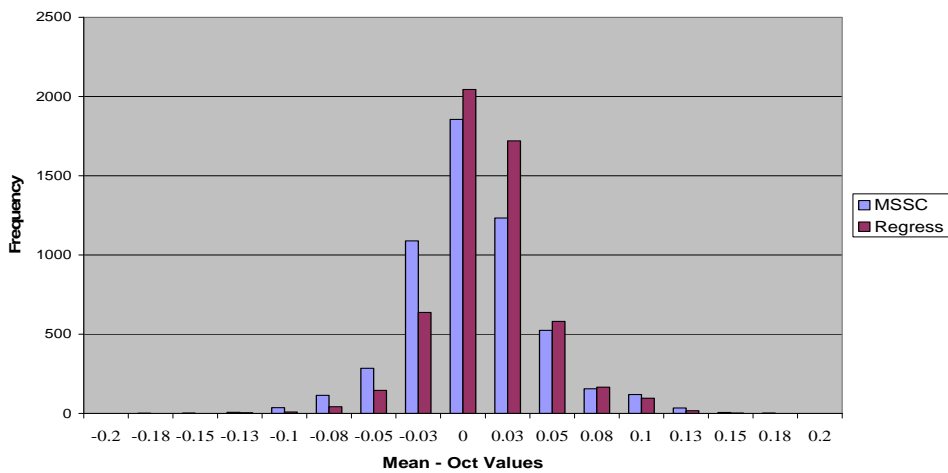
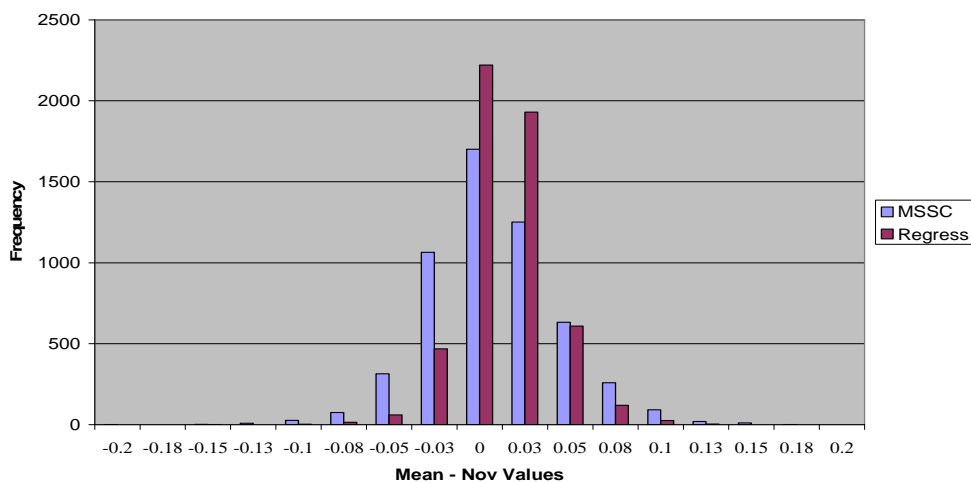


Figure 17 November Values Subtracted from the Mean - Decreasing Direction



For October and November in the decreasing direction, Figures 16 and 17, the results using the regression procedure lay closer to the zero value.

The histogram for the corrected January data, Figure 18, has a positive skew but again the data from the regression procedure is banded closer to the zero value than the data from the single factor procedure.

Figure 18 January Values Subtracted from the Mean - Decreasing

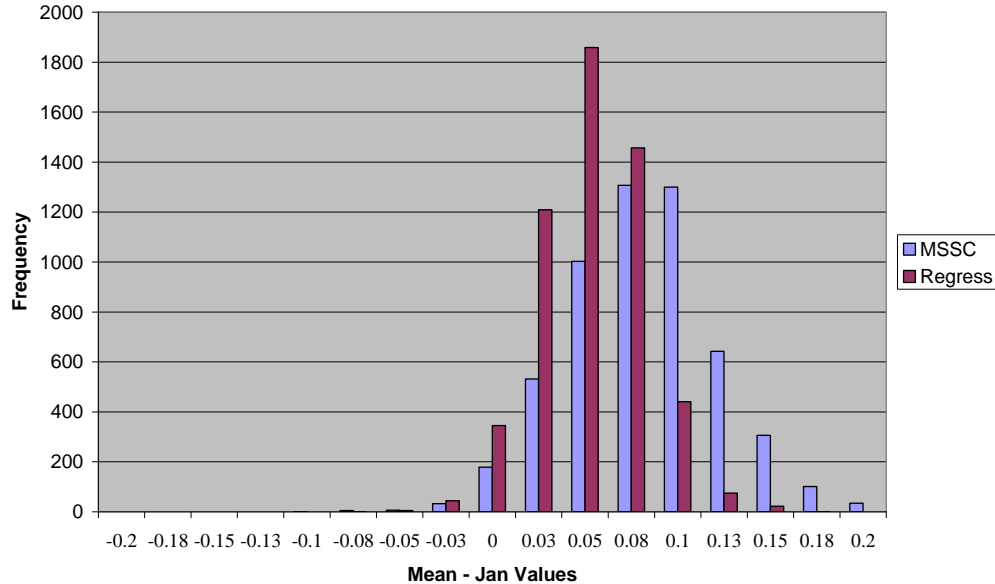
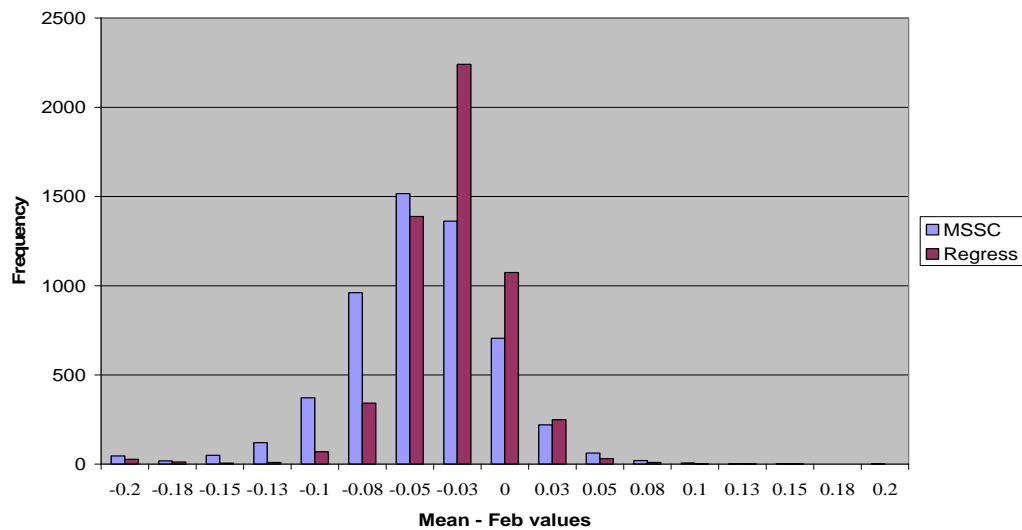


Figure 19 February Values Subtracted from the Mean - Decreasing



The histogram for the February values Figure 19 shows a negative skew but again the data from the regression procedure lay closer to the zero value than for data corrected using the single factor procedure.

Thus far, all the data has been used in the graphs which can be confusion because of the sheer quantity. To present the information in a clearer form the data from a typical 3km stretch of road has been extracted and shown in Figures 20 to 22 in order to more clearly see the different output from each of the methods.

Figure 20 **Uncorrected SC Values**

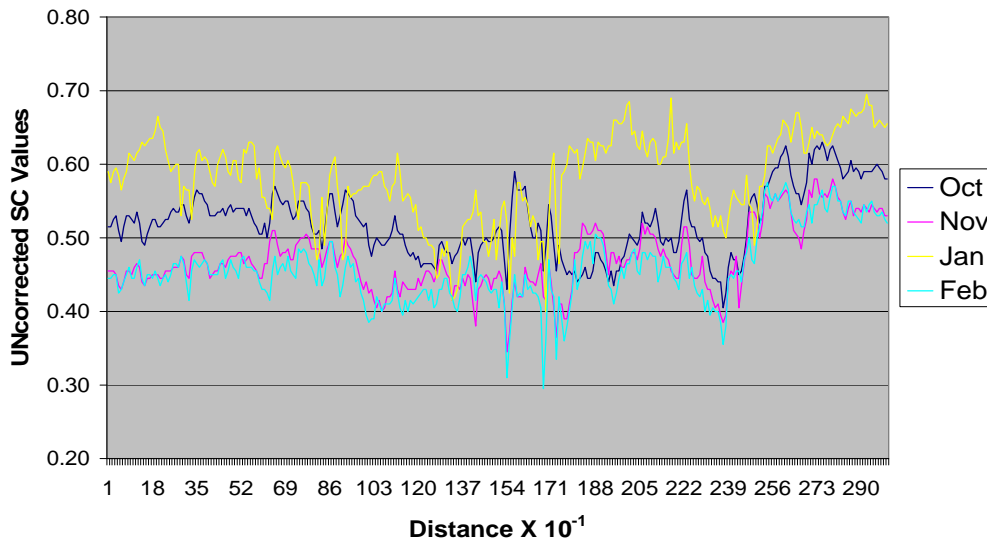


Figure 21 **SC Values Corrected by Single Factor**

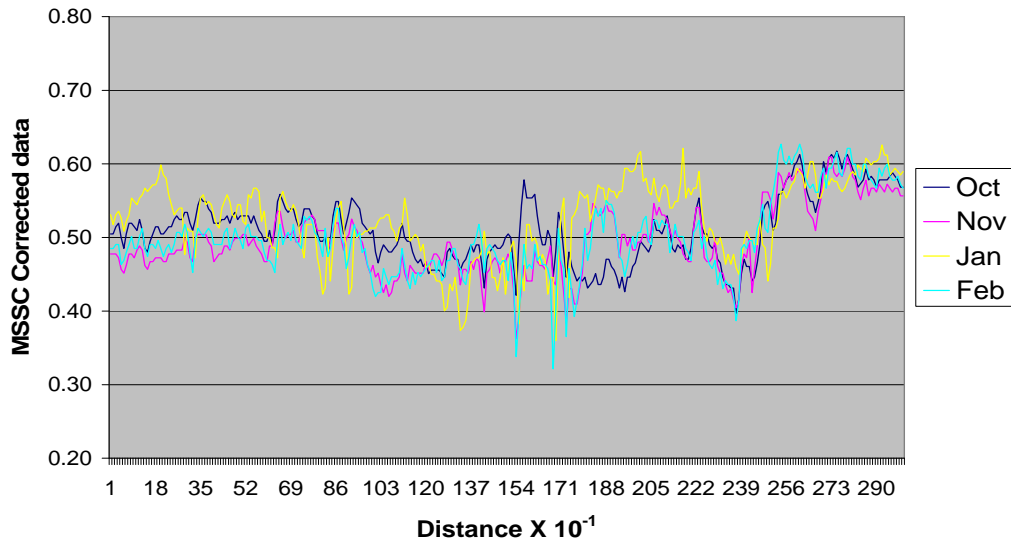
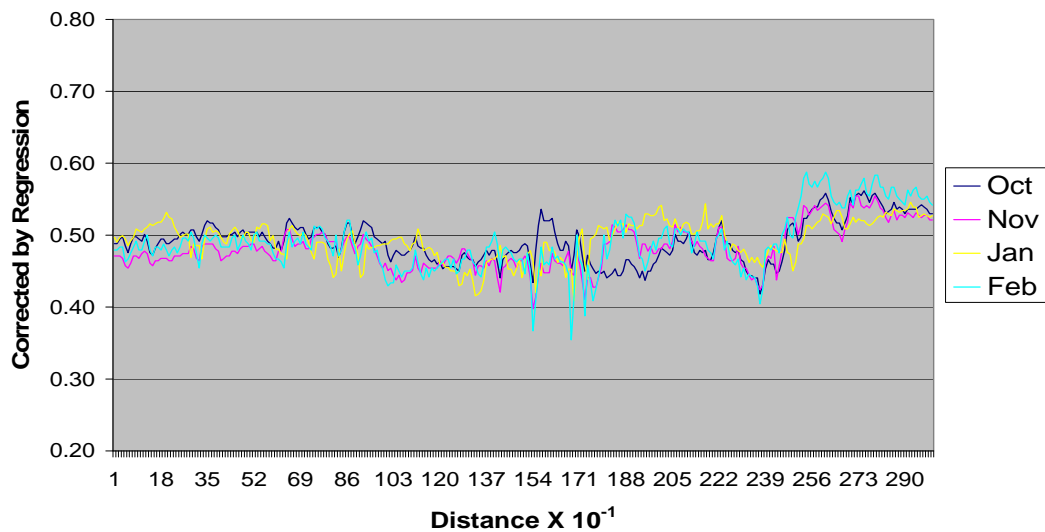


Figure 22 **SC Values Corrected by Regression**



Using a 3 km of data it can be seen quite clearly that the single factor correction has successfully adjusted the SC values and contracted the extreme values closer to the

mean. The regression procedure also does this but further reduces the difference between each of the surveys.

The evidence from this study has shown that the regression procedure is an improvement over the single factor method for correcting SC values for within year seasonal variations.

2.3.5 Correcting for between Year Seasonal Effects

In New Zealand a four year rolling average is used for the correcting the between year seasonal variation. The mean of 4 annual MSSC values is calculated and this mean is used to produce an Equilibrium SCRIM Coefficient (ESC) factor for the fourth year. The fourth year area MSSC values are corrected for between year variations by applying the ESC factor. In the following year, the first year will drop off and the new years MSSC will be added. The sites used to calculate the ESC have to be the same for the four years.

This approach has been satisfactory and certainly better than not correcting for the between year seasonal effects but this process also uses a single factor to make adjustments which as discussed can lead to errors at the extremes.

Although the actual analysis has not been carried out at this stage, a regression procedure as shown in the stages below can be used.

Stage 1 Obtain the uncorrected of 10m data for the each run for all the 1km control sites in the seasonal control area. The Stage 1 text box below illustrates the uncorrected data (X, Y and Z) from a control site in 2002.

Stage 2 Calculate the mean for the three runs for each 10m of the control sites in the area. This is illustrated (A) by the Stage 2 text box.

Stage 3 Stage 2 needs to be repeated for the following three years used in the analysis ie 2003, 2004, and 2005 to produce the mean for the three runs for each year for each 10m length for all the control sites in the area. This is illustrated in the Stage 3 text box (A, B, C and D).

Stage 4 Calculate the mean for each 10m for all four years This is illustrated (A1) in the Stage 4 text box.

The regression equation is obtained by plotting the mean from the current year in stage 3 against the mean for all years in stage 4. The regression equation from this plot can be used to adjust all 10m SC values in the area that have already been corrected for within year seasonal effects to obtain value that are corrected for within and between year seasonal effects.

Uncorrected Data 2002		
X	Y	Z
X	Y	Z
X	Y	Z
X	Y	Z

Stage 1

Mean 10m values for Data
A
A
A
A

Stage 2

Repeat the above stages for 2003, 2004 and 2005.

Mean of 10m Values for Each Year			
2002	2003	2004	2005
A	B	C	D
A	B	C	D
A	B	C	D
A	B	C	D

Stage 3

Mean for all years
A1
A1
A1
A1

Stage 4

3.0 CONCLUSIONS

The current single factor procedures adjusting the SCRIM results for within and between year seasonal variations has been compared with a regression procedure. The single factor procedures have worked well in the past but since they correct using single values there is a possibility of errors emerging when dealing with data that has a large range.

The regression procedure provides a proportional factor for each 10m SC value and does not only allow for a one to one relationship.

The results for the within year adjustments for the study data showed quite clearly that the regression procedure was superior to the MSSC approach.

Reducing the errors in the extreme vales for the seasonal correction procedure by adopting the regression approach will reduced the amount of low values and this will reduce the amount of unnecessary investigation by the responsible highway authority and improve the credibility of the whole skid resistance policy process.

Within the paper, a regression procedure has also been presented as an alternative to the ESC procedure currently used to adjust the SCRIM data for between year variations.

References

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