THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION RESEARCH GRANT

NGR-14-007-027

(Principal Investigator: E. H. Timothy Whitten)

NORTHWESTERN UNIVERSITY REPORT NUMBER 21

A FORTRAN IV PROGRAM FOR TWO-DIMENSIONAL AUTOCORRELATION ANALYSIS OF GEOLOGIC AND REMOTE-SENSED DATA

by

W. B. HEMPKINS

DEPARTMENT OF GEOLOGICAL SCIENCES
NORTHWESTERN UNIVERSITY
EVANSTON, ILLINOIS
60201

ISSUED FEBRUARY 11, 1970

The National Aeronautics and Space Administration Research Grant

NGR-14-007-027

Statistical evaluation of the composition, physical properties, and surface configuration of terrestrial test sites and their correlation with remotely-sensed data

REPORT NUMBER 21

A FORTRAN IV PROGRAM FOR TWO-DIMENSIONAL AUTOCORRELATION ANALYSIS OF GEOLOGIC AND REMOTELY-SENSED DATA

By

W. B. Hempkins
(now of CHEVRON OIL FIELD RESEARCH COMPANY, LA HABRA, CALIFORNIA)

Department of Geological Sciences, Northwestern University,
Evanston, Illinois 60201

February 11, 1970

CONTENTS

PREFACE

The Northwestern University team has maintained a continuing interest in the statistical evaluation of the composition, physical properties, and surface configuration of the lithosphere-atmosphere interface. Such evaluation is a necessary prelude to understanding the correlations between remotely-sensed data and 'ground truth'.

Assessing the nature and variability of measurable variables of the lithosphere still presents many unsolved problems. In the course of his Ph.D. research at Northwestern University, Hempkins attempted to evaluate some of the more widely used techniques for developing and interpreting trend surfaces. In his thesis, he established that two-dimensional autocorrelation analysis is a useful tool in this regard - equally valuable in analyzing data for remote-sensing purposes and for evaluating most other mapped variables of interest in the earth sciences.

The final stages of preparing this manuscript were completed in 1969 after Dr. Hempkins had joined the Chevron Oil Field Research Company, La Habra, California.

E. H. Timothy Whitten

ABSTRACT

The mathematical development and logic for computing a two-dimensional autocorrelation analysis of mapped data is given. Examples of usage of this type of analysis for studying mapped structures and testing statistical properties of trend surface maps and their residual maps are given. A FORTRAN IV computer program for the IBM OS 360/50 is listed. Operating instructions, sample data, and specimen output are also given in detail.

INTRODUCTION

Criteria for recognition of "trend" (signal) from "noise" for geologic data have been proposed by many workers (cf. Grant, 1957; Krumbein, 1966, 1967; James (1966); Esler and Preston (1967); Hempkins (1969)). These criteria may be generally classified by:

1. Fulfillment of basic model assumptions Grant (1957); James (1966); Krumbein (1966); Hempkins (1969).

2. Frequency content of the data (Esler and Preston (1967); Hempkins (1969)).

3. A combination of (1) and (2) either implicitly or explicitly Grant (1957); James (1966); Hempkins (1969)).

It is the purpose of this paper to describe a time series analysis method for use in testing trend surface techniques for all the above criteria. This method may also be used to quantitatively describe the generalized fabric of a set of mapped data and to study patterns among maps.

Classical time series analysis, while well established by the late 1930's, has been relatively neglected by geologists largely because most geologic measurements are not readily collected as a function of time. It is, however, a relatively easy transition from the time domain to the space domain using the classical methods of time series analysis. The autocorrelation function is one of the simpler and more useful techniques of studying such a series. Studies dealing with the autocorrelation function of several types of geographically distributed geologic data have been presented by Grant (1957), Horton et al (1962), Matalas (1963) and enlarged by Horton et al (1964), Agterberg (1965) and Preston (1966). Only Horton et al (1962 and 1964) (1966) and Preston treated the subject for two mathematical dimensions.

The serial correlation coefficient was proposed by Yule (1927) as a test of linear dependence of a given sample upon preceding samples as

$$\hat{r}_k = \frac{\frac{1}{N-k}\sum_{i=1}^{N-k} x_i x_{i+k} - \frac{1}{(N-k)^2}\left(\sum_{i=1}^{N-k}\right) x_i \left(\sum_{i=1}^{N-k}\right) x_{i+k}}{\left[\frac{1}{N-k}\sum_{i=1}^{N-k} x_i^2 - \frac{1}{(N-k)^2}\left(\sum_{i=1}^{N-k} x_i\right)^2\right]^{\frac{1}{2}}\left[\frac{1}{N-k}\sum_{i=1}^{N-k} x_{i+k}^2 - \frac{1}{(N-k)^2}\left(\sum_{i=1}^{N-k} x_{i+k}\right)^2\right]^{\frac{1}{2}}}, \quad (1)$$

where

$$\hat{r}_o = 1 \quad (2)$$

and

$$\hat{r}_k = \hat{r}_{-k}. \quad (3)$$

x_i and x_{i+k} are the events at time i and i+k respectively, N is the number of events forming the time series and r_k is the kth-order serial correlation coefficient. If the set of data values is randomly distributed in time r_k will have an expectation of zero for $k \neq 0$.

Wiener (1930, 1948) proposed that for a given series x_i there exists a function

$$C(t) = E\{X_i X_{i+\Delta t}\} \tag{4}$$

which he termed the autocovariance function. He further showed that if this function possessed a Fourier transform, then

$$P(w) = \int_{-\infty}^{+\infty} e^{iwt}\, C(t)dt\ , \tag{5}$$

where P(w) is the power spectrum or power density function and w is the frequency. The inverse transform of P(w) yields C(t).

If it is assumed that the last event of a series is followed by the first event, Anderson (1942) gave the circular definition of the serial-correlation coefficients by

$$\hat{r}_k = \frac{\frac{1}{N}\sum_{i=1}^{N} x_i x_{i+k} - \frac{1}{N^2}\left(\sum_{i=1}^{N} x_i\right)^2}{\frac{1}{N}\sum_{i=1}^{N} x_i^2 - \frac{1}{N^2}\left(\sum_{i=1}^{N} x_i\right)^2} \tag{6}$$

Blackman and Tukey (1959) demonstrated that the power spectrum could be obtained from the numerator of equation (6) (the autocovariance function) by

$$\hat{P}_r = \Delta X \left[C_o + 2 \sum_{p=1}^{M-1} C_p \cos(Pr\pi/m) + C_M \cos r\pi \right] \qquad (7)$$

$$r = 0, 1, 2, 3, \ldots, m$$

where ΔX is the sampling interval and $(m+1)$ is the number of autocovariance estimates (C_i).

Cote, et al. (1960) and Horton, et al. (1962) independently extended the above equations into two dimensions, although the former gave the more definitive exposition of the power spectrum. The two-dimensional autocovariance function was given by Horton, et al (1962) as

$$C(r,s) = \frac{1}{(N-r)(M-s)} \sum_{i=1}^{N-r} \sum_{j=1}^{M-s} X(i,j)X(i+r,j+s) , \qquad (8)$$

$$r, s = 0, 1, 2, \ldots, n, m$$

where the X_{ij} have zero mean, r and s are row/column lag indices, and M and N are map dimensions. In the one-dimensional case, the autocorrelation function is an even function, i.e., the negative correlation values are equal to the positive correlation values for a given lag. Unlike the even one-dimensional function, the negative shift of the two-dimensional function must be defined as

$$\hat{C}(r,-s) = \frac{1}{(N-r)(M-s)} \sum_{i=1}^{N-r} \sum_{j=s+1}^{M} X(i,j)X(i+r,j-s) \, , \tag{9}$$

$$r, s = 0, 1, 2, \ldots, n, m$$

and

$$\hat{C}(r,s) = \hat{C}(-r,-s) \; ; \; \hat{C}(-r,s) = \hat{C}(r,-s) \, . \tag{10}$$

Anderson (1942) developed a test of significance for the one-dimensional case. Demonstrating for a random gaussian time series that r_1 is approximately normally distributed with mean (-1/N-1) and variance ((N-2/(N-1)^2), his test of significance can be approximated by

$$r_1 = \frac{-1 \pm t_\alpha \sqrt{N-2}}{N-1} \, , \tag{11}$$

(Cf. Agterberg (1965)) where t_α is the standard normal variate corresponding to a probability level α. If $\hat{r}$ is greater than r_1, then $\hat{r}_1$ is considered to be significantly different from zero. In order to define r_n for any lag, Agterberg (1965) established the confidence band about r_k by linearly extending the above equation. Due to the loss of degrees of freedom for a finite record, this relationship is redefined here as

$$\hat{r}_K = \frac{-1 \pm t_\alpha \sqrt{N-K-2}}{N-K-1} \, , \tag{12}$$

where K is the lag number in terms of the sample interval. For purposes of this paper, the test of significance is extended to two dimensions as

$$\hat{r}_{K,L} = \frac{-1 \pm t_\alpha \left((M-K)(N-L)-2\right)^{\frac{1}{2}}}{(M-K)(N-L)-1} . \qquad (13)$$

In practice the autovariance function is normalized by defining the autocorrelation function as

$$r(K) = \frac{C(K)}{C(0)} , \qquad (14)$$

and two dimensionally as

$$r(K,L) = \frac{C(K,L)}{C(0,0)} . \qquad (15)$$

Expressed in this form it is identical to the definition of the serial correlation coefficient. The notation autocorrelation and serial correlation will therefore be synonymous.

MATHEMATICAL AND GEOMETRIC PROPERTIES OF THE TWO-DIMENSIONAL AUTOCORRELATION FUNCTION

In general, the one-dimensional autocorrelation function will exhibit, to some degree, the following characteristics of a data set:

1. Degree of mutual dependence of the elements in the data set.

2. Presence of harmonic components.

In addition to the above, the two-dimensional function will preserve:

1. Structural symmetry of the map, and

2. All major directional attributes of the map.

A further property of both functions is that if two different data sets are subjected to cross correlation only the elements common to both sets are preserved.

If one assumes that a geologic response is represented by:

$$F(x,y) = G(x,y) + \varepsilon(x,y) \qquad (16)$$

where $\varepsilon(x,y)$ represents uncorrelated residuals, then

$$E\,\{C(F(x,y))\} = C(G(x,y));\ E\,\{C(\varepsilon(x,y))\} = 0 \qquad (17)$$

should hold provided $\sigma_G^2 >> \sigma_\varepsilon^2$. It can also be shown that G(x,y) need not possess any particular mathematical characteristics, that is, G(x,y) may be any type of function. It is possible in many cases (Cf. Matalas (1963)) to predict the function G(x,y) from its autocorrelation function. This is, however, probably not the general case for geologic data, and we merely seek the autocorrelation function for a given set of regularly spaced data in order to interpret the geometric properties of the map. It can further be demonstrated that the data record need not be composed of continuous data but may also be discontinuous in nature. In this case the autocorrelation function will still maintain the above described properties. For examples of the use of discontinuous data, see Hempkins (1969).

PROGRAM HISTORY AND DEVELOPMENT

The present program for two-dimensional autocorrelation analysis is based on the theory set forth by Horton, et al (1962). The original program logic was developed for a CDC 1604 computer at the University of Texas by Dr. A. A. J. Hoffman. Subsequently, this program was discarded, and a new program was written by the writer for the IBM 7094 at Northwestern University in 1964. It was further revised by the writer for the CDC 3400 at Northwestern University in 1966. In 1966 the program was modified to include the test of significance as explained in the preceding section. The present version has been adapted to the IBM OS 360/50.

SAMPLE DATA

Several examples of data for use in testing this program will be given. However, only one set will be used to illustrate the complete program output.

AUTOCORRELATION STRUCTURE OF RANDOM DATA

Table 1 lists a 20 x 20 array of rectangularly distributed random numbers taken from Table A10 of Krumbein and Graybill (1966). The lower half of the two dimensional autocorrelation function (both positive and negative shifts) as computed by program GEOCOVR is given in Table 2. Coefficient estimates significant at the 95% probability level as given by equation 13 are underlined. As can be seen, there is no general pattern to the distribution of the significant coefficients. This is expected for a geographically random distribution of numbers.

RANDOM NUMBERS SUBJECTED TO AUTOCORRELATION PROCEDURES

Table 3 lists the random numbers of Table 1 after those values were subjected to a two-dimensional simple moving average with a window of 2 x 2 data units. Such a process,

608	809	852	841	644	900	195	493	631	609	5	923	835	108	217	321	963	398	779	579
381	731	75	756	595	540	396	125	636	385	940	306	113	384	741	83	24	628	283	654
117	605	785	92	233	611	154	731	52	123	85	404	748	338	252	458	169	865	128	420
662	299	963	506	783	510	454	209	633	366	17	895	201	687	800	164	416	507	64	80
154	927	145	230	88	586	636	808	60	439	481	288	210	822	949	969	744	354	803	647
444	489	689	964	810	549	12	448	894	30	122	893	565	274	97	707	457	895	115	357
775	20	129	649	647	405	945	374	932	734	687	66	36	230	822	991	553	787	326	565
210	344	10	584	420	44	526	274	747	121	474	310	311	44	816	751	46	23	15	711
0	278	506	699	638	583	985	243	132	431	611	747	423	20	875	666	791	211	916	123
432	894	326	970	288	78	321	395	481	918	280	107	418	447	693	626	695	295	93	87
412	408	303	35	554	981	759	604	995	897	292	284	958	599	807	155	932	622	364	385
657	677	238	971	569	281	339	100	505	793	444	688	860	703	570	542	199	160	333	288
580	954	248	139	432	457	270	729	622	52	811	362	292	521	160	506	716	235	693	926
240	463	929	105	369	102	440	631	916	519	138	262	17	817	788	310	225	20	344	487
482	161	277	857	740	427	605	592	105	274	418	198	755	784	378	477	799	90	43	502
212	228	702	667	160	549	431	542	214	744	692	477	830	71	613	527	537	476	914	248
979	696	484	499	8	30	29	401	844	639	775	275	994	364	152	851	553	212	914	374
671	145	839	353	369	745	535	358	451	419	117	58	883	385	4	493	317	178	745	40
507	120	512	349	164	310	570	442	735	556	588	229	169	42	883	68	261	286	21	82
982	619	941	614	570	366	392	230	51	963	771	917	32	542	491	192	936	579	509	78

Table 1. 20 x 20 array of 400 rectangularly distributed random numbers, range 0-999.

POSITIVE SHIFT AUTOCORRELATION MATRIX

1.000+000	1.465-002	-5.091-002	-2.954-002	-4.764-002	-6.481-002	4.942-002
-6.370-002	-5.647-002	3.474-002	5.483-003	1.815-003	1.471-002	1.375-001
2.088-002	-5.792-002	2.407-002	6.532-002	-8.125-002	-8.082-002	2.144-002
-1.992-002	4.504-002	5.023-002	-7.964-002	-6.551-002	-7.993-002	5.190-002
-1.688-002	-2.639-002	2.072-002	-1.038-001	4.362-002	3.095-002	-5.332-002
5.695-002	8.782-003	-1.241-002	1.282-002	8.968-002	5.929-002	1.179-002
-4.396-002	1.348-001	3.311-002	5.542-002	3.949-002	-5.426-002	-1.158-001
-2.961-002	-8.303-002	-7.522-002	-3.350-002	-3.201-002	-4.040-002	-1.431-002
3.456-004	-6.240-002	-4.749-002	-4.325-003	4.562-002	-7.951-002	1.500-001
-8.253-002	8.480-003	3.571-002	-1.278-001	7.016-002	-2.874-002	-4.602-002

NEGATIVE SHIFT AUTOCORRELATION MATRIX

4.942-002	-6.481-002	-4.764-002	-2.954-002	-5.091-002	1.465-002
-8.225-002	-5.226-002	-3.953-002	2.086-002	2.743-002	-7.464-002
1.098-001	2.199-002	5.822-002	-3.548-002	-5.104-002	2.952-002
2.428-002	4.220-005	-1.466-001	-7.017-002	-7.583-002	-5.397-003
-8.797-003	1.953-002	-1.061-001	-4.693-003	1.408-001	9.701-002
-3.222-002	5.374-003	4.948-002	1.205-001	-2.194-003	-5.915-002
4.447-002	5.690-002	-2.389-002	-1.366-001	9.173-002	-1.552-002
2.760-002	-9.701-002	9.516-002	-6.681-002	-3.762-002	4.204-002
-3.229-002	-1.932-002	-9.310-002	7.177-002	5.975-002	-1.870-002
2.444-002	5.543-002	2.039-002	2.299-002	-7.272-002	7.261-004

Table 2. Values for lower half of autocorrelation matrix of numbers in Table 1. Underlined values are significantly different from zero at 99 percent level of probability. The right-most four places of the number indicates the power of ten by which the coefficient is scaled.

which consists of averaging overlapping areas of the data, introduces a positive dependence between the previously uncorrelated numbers. Figure 1 gives a contour map of the positive autocorrelation coefficients which are significant at the 95% probability level. Only the positive coefficients are contoured as the negative coefficients in this case are expected to be randomly distributed, as are all positive coefficients after the first zero crossing (see Jenkins and Watts, 1968, p. 160, 161). This example demonstrates how one can ascertain if there is a geographic dependence between variables.

A GEOLOGIC EXAMPLE

Appendix A lists a 13 x 18 array of gold values taken from maps presented by Krige (1965) and Whitten (1965, 1967). The values are spaced at 50-foot intervals and are moving average values of original ore samples prepared in a manner described by Krige and Ueckermann (1963) and Hempkins (1969). These moving averaged values are contoured in Figure 2.

Appendix B, in addition to giving a listing of program GEOCOVR, contains the results of the autocorrelation computations for the data of Appendix A. The autocorrelation function of these data is contoured in Figure 3 and clearly shows the northwest-southeast fabric of the original map. Further,

480	209	421	505	486	563	440	608	670	298	499	791	803	788	420	367	473	354	275
400	325	618	809	535	458	430	430	516	457	640	611	431	406	469	562	421	352	268
290	488	633	546	518	669	728	461	456	543	578	468	207	270	528	602	452	543	357
332	400	635	401	290	446	685	639	406	390	499	451	271	267	237	309	554	579	249
217	354	685	478	281	451	499	417	402	462	515	389	217	217	276	299	488	683	371
274	355	582	572	602	808	437	155	429	469	331	233	320	497	466	424	518	579	451
630	514	501	577	721	874	414	194	410	432	352	433	612	733	683	620	691	644	594
405	332	396	493	513	509	255	258	437	399	343	476	485	611	760	797	795	781	703
388	365	469	544	542	487	333	403	439	467	428	313	404	655	697	527	489	635	542
653	551	601	449	581	835	543	370	519	577	414	398	563	672	588	307	456	561	478
504	455	546	551	564	616	351	221	501	554	290	302	362	533	402	275	589	498	549
497	474	473	607	629	380	126	145	272	452	397	355	388	506	469	433	672	623	459
655	514	393	550	737	424	148	299	522	475	459	650	634	417	472	561	669	580	381
585	394	347	453	641	496	209	383	629	583	600	720	577	399	504	506	413	403	590
522	318	277	387	667	717	375	311	511	584	517	586	504	341	449	411	410	542	561
478	390	265	283	676	869	591	381	454	472	390	452	581	472	382	428	533	478	290
464	472	293	147	299	620	642	478	442	395	323	303	385	583	634	519	439	343	465
365	448	332	153	285	633	611	583	561	369	371	459	422	596	821	680	472	437	738
386	572	535	252	482	707	566	776	714	532	559	662	663	642	611	670	612	370	554

Table 3. Values of Table 1 subjected to a simple moving average of average window extent 2 x 2.

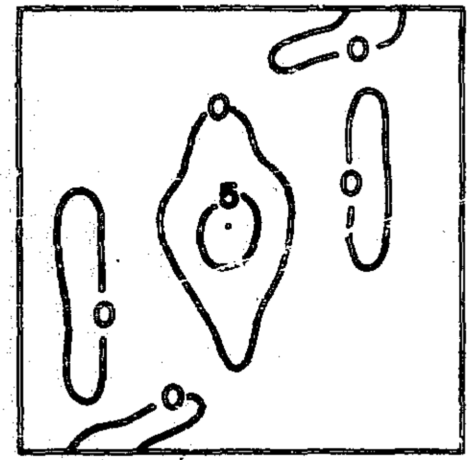


FIGURE 1

AUTOCORRELATION OF MOVING AVERAGE VALUES OF TABLE 3.
ONLY POSITIVE, SIGNIFICANT VALUES (95 PERCENT LEVEL) CONTOURED.

regarding $|C(r,s)|>.2$ as being significantly different from a coefficient of zero, the average structural element of the autocorrelation function persists for about 600 ft in the northwest-southeast direction (direction of minimum variation) and about 200 ft in the northeast-southwest direction (direction of maximum variation). The length in the direction of maximum variation is consistent with that observed in the original data. The length in the direction of minimum variation is, however, a compromise between the dominant central ridge and the smaller isolated regions. Nevertheless, this distance is probably a reasonable estimate of the average structural persistence in the direction of minimum variation of the original map.

Whitten (1965, 1967) conducted polynomial trend surface analyses of the area presented by Krige (1965). The data of Appendix A is a subset of that reported by these writers. Hempkins (1969) studied the use of both polynomial and double Fourier trend surface techniques for ore valuation of this data. In Figure 4, cubic and sextic polynomial trend surfaces are compared with first and second harmonic Fourier trend surfaces for the data of Appendix A. In general, the Fourier surfaces appear more like the contoured data. However, the sums of squares reduction (SS) is similar for each of the compared cases for both models. Residuals from each surface are given in Figure 5.

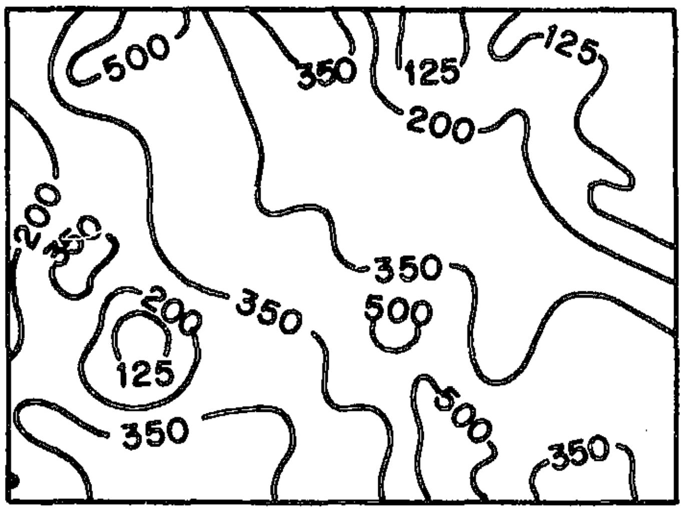


FIGURE 2

MANUALLY CONTOURED MAP OF GOLD DATA OF APPENDIX A.
VALUES IN INCH–DWT. CONTOUR INTERVAL AS SHOWN.
SCALE AS IN FIGURE 3.

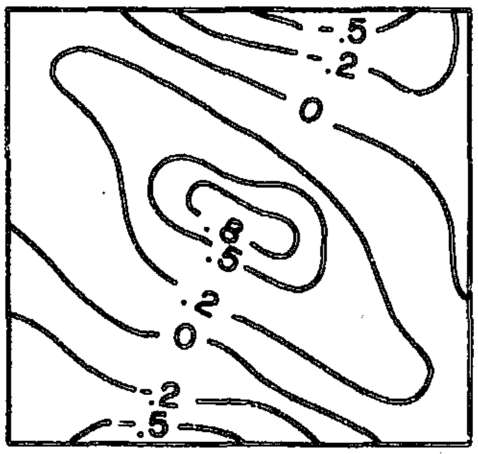
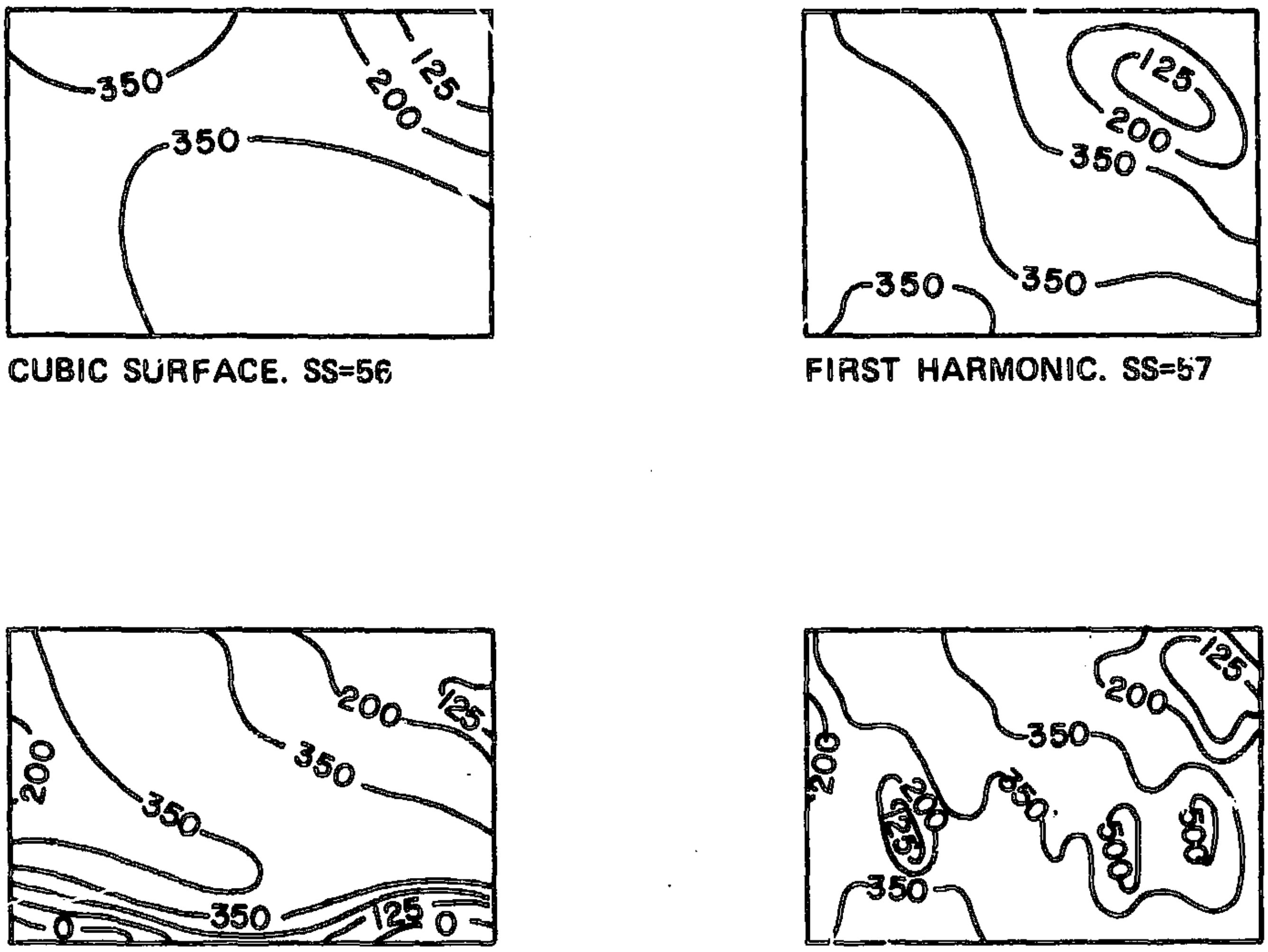


FIGURE 3

MANUALLY CONTOURED MAP OF TWO DIMENSIONAL AUTOCORRELATION COEFFICIENTS (21 LAGS, SQUARE) FOR DATA OF APPENDIX A.

SCALE



POLYNOMIAL

CUBIC SURFACE. SS=56

SEXTIC SURFACE. SS=57

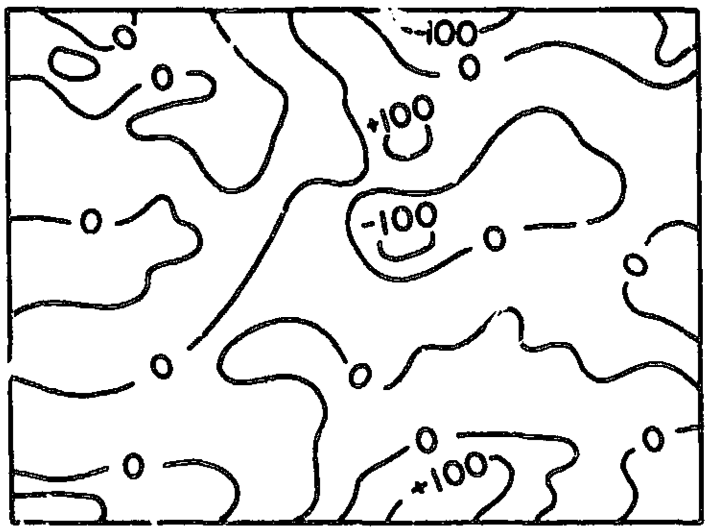
FOURIER

FIRST HARMONIC. SS=57

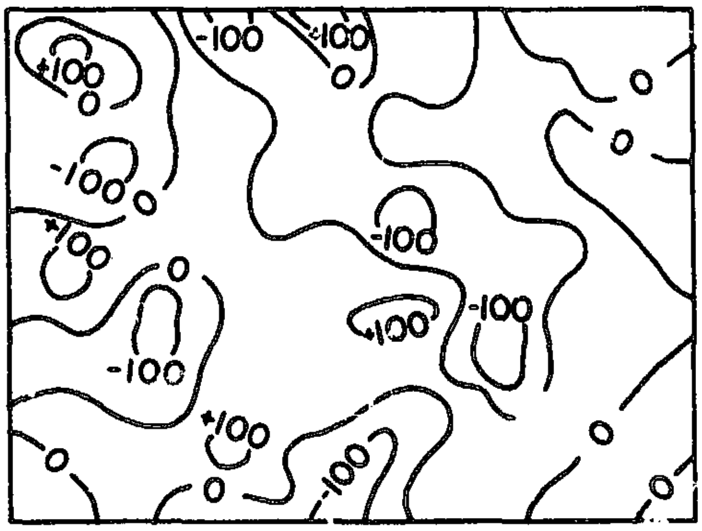
SECOND HARMONIC. SS=74

FIGURE 4

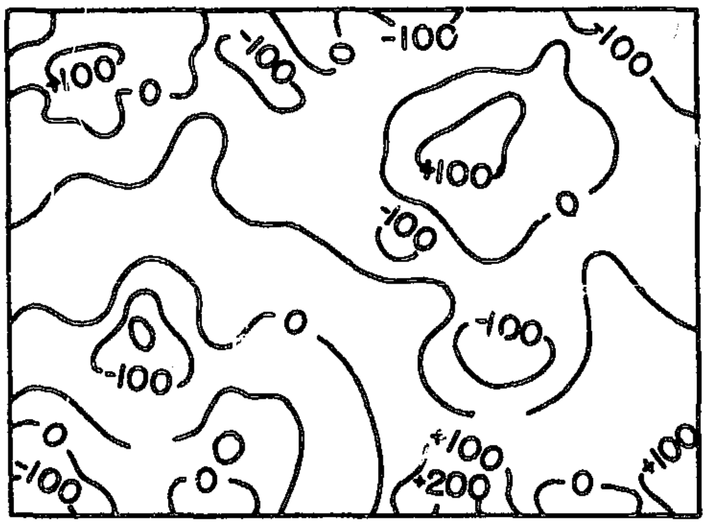
POLYNOMIAL AND FOURIER FITS TO DATA. SCALE OF MAPS IS 650 X 900 FT.



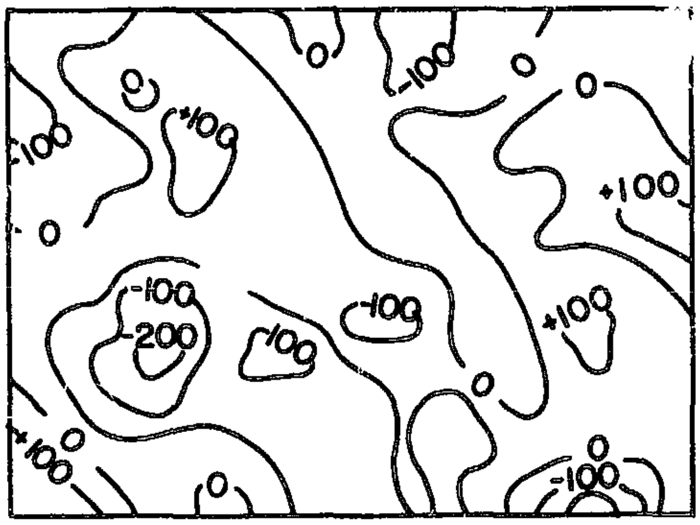
RESIDUALS ABOVE FIRST HARMONIC SURFACE. C. I. = 100 IN.–DWT.



RESIDUALS ABOVE CUBIC SURFACE. C. I. = 100 IN.–DWT.



RESIDUALS ABOVE SECOND HARMONIC SURFACE. C. I. = 100 IN.–DWT.



RESIDUALS ABOVE SEXTIC SURFACE. C. I. = 100 IN.–DWT.

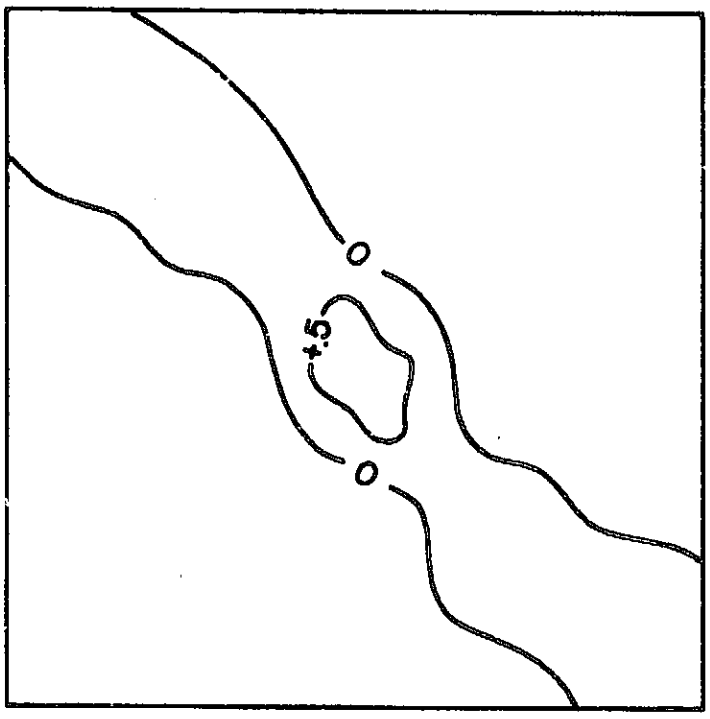
FIGURE 5

RESIDUALS ABOVE FOURIER AND POLYNOMIAL MAPS FOR DATA. SCALE OF MAPS IS 650 X 900 FT.

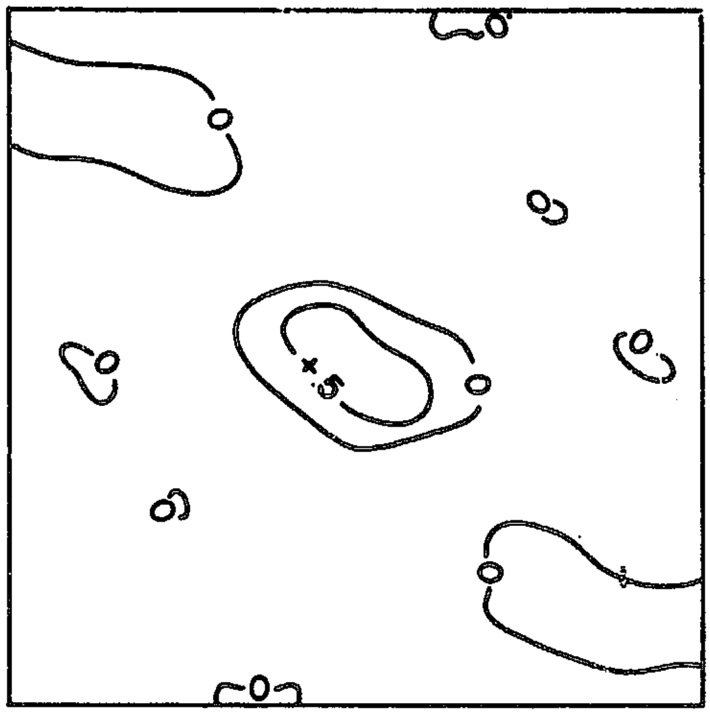
In order to fulfill the assumptions made by Grant (1957), these residuals should be randomly distributed. This implies that $E[C(r,s)] = 0$ for the residual values, for $r + s \neq 0$.

The autocorrelation functions for each of the residual maps is presented in Figure 6. It is obvious that all of the residual maps possess some autocorrelation structure, the orientation of which is consistent with the original data. The persistent ridge in the autocorrelation map of the residuals from the cubic appears to contain more "trend" than does the same map for the first harmonic surface. Study of the residual maps of Figure 5 shows that this is probably true. Further, as the structural persistence of the autocorrelation function should decrease as the residuals become randomly distributed, it does not appear that the higher order surfaces significantly improve the trend determination given by the first harmonic. The central area of each autocorrelation map is a result of the moving average process and could never be eliminated by trend analysis. Considering this, one might wish to accept the second harmonic surface as the better "trend" description.

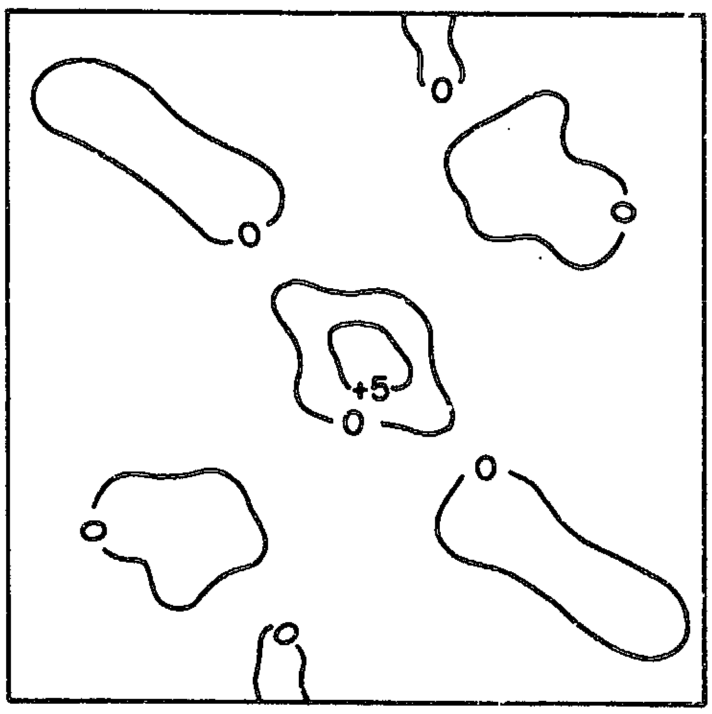
Studies of this sort can be used to compare complex maps between different variables measured over the same area in order to determine the similarity of geographic distributions. Horton, Hoffman, and Hempkins used the technique to study the topography of a lake bottom from echo soundings (1962) and to infer structural fabric and fault movements (1964).



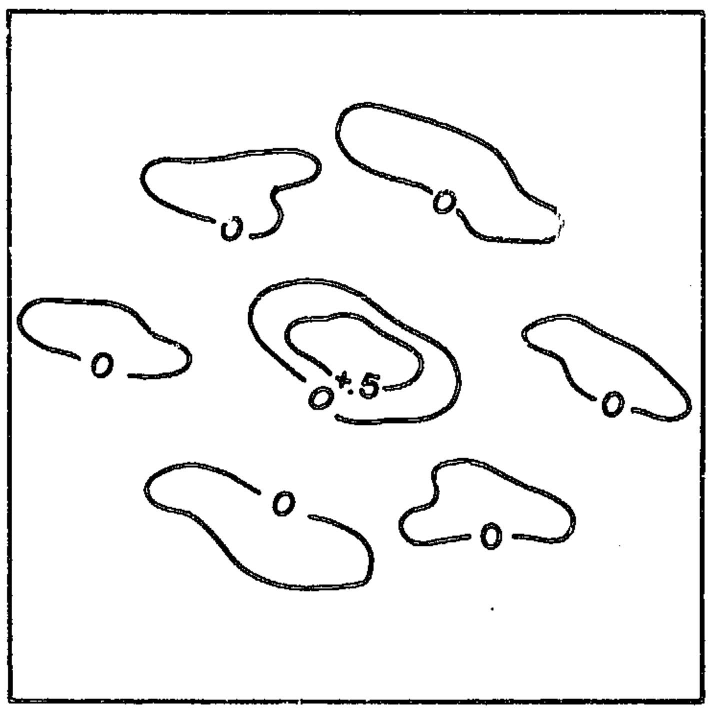
RESIDUALS FROM CUBIC MAP.



RESIDUALS FROM FIRST HARMONIC MAP.



RESIDUALS FROM SEXTIC MAP.



RESIDUALS FROM SECOND HARMONIC MAP.

FIGURE 6

AUTOCORRELATION MAPS OF RESIDUAL SURFACES OF FIGURE 5
ONLY COEFFICIENTS SIGNIFICANT AT THE 99 PERCENT PROBABILITY
LEVEL ARE CONTOURED.

Hempkins (1969) used the technique to aid in designing a weighting function for a moving average model. He also used this method to determine how various data preprocessing steps affected the mathematical and statistical results of several trend surface models.

PROGRAM USE

The present version of program GEOCOVR has been designed for maximum flexibility and minimum user specification of parameters. All major control parameters are read via a namelist, COVR, of the following form.

NROW - the number of rows of the data matrix

NCOL - the number of columns of the data matrix

NFILR - the number of rows of the filter matrix

NFILC - the number of columns of the filter matrix

NRLAG - the number of row lags of the autocorrelation function.

NCLAG - the number of column lags of the autocorrelation function.

IRLAG - row/column decimation intervals so that
ICLAG alternate data rows and columns may be omitted from the autocorrelation computation.

IPR - Control parameter for suppressing intermediate output.

IREAD - Control parameter for reading input data matrix.

All parameters can be defaulted but NROW and NCOL which are required for data input. If ICLAG and IRLAG are defaulted, the program sets them equal to 1 and computes only the zero lag (data variance) coefficient. This default was used to prevent abnormal termination of a sequence of problems due to a failure to specify the necessary parameters for one or more problems.

The standard defaults are:

IPR = 1 Suppress all intermediate output, listing only the original data, the levelled data, the autocorrelation estimates and map. (See Problem 2, Appendix B.)

If	IPR = 0	all intermediate printing is given. See Problem 1, Appendix B)
	IPR = 2	Gives all intermediate printing but suppresses the confidence computation.
	IPR = 3	Suppresses all intermediate printing but gives confidence computation.
	IREAD = 0	assumes that there is one data value per card such as that given in Appendix A. Cards must be ordered by rows. If IREAD = 1, it is assumed that data is sequentially recorded in equal increments by rows.
	NFILC = 1 NFILR = 1	Assumes that no filtering is desired in which case the filter matrix is +1.0 and forms the last card of the data deck. Any other value of NFILR or NFILC requires that there be NFILR rows and NFILC columns of filter coefficients to be read by a user supplied format. The format (<u>FILFMT</u>) <u>is</u> required regardless of the values of these variables.

ICLAG = 1 Assumes all input data will be used in
IRLAG = 1 computation. Any other value of these parameters will perform computations in increments of the input values. For example, ICLAG = IRLAG = 2 would cause every other row and column to be omitted from computation.

Other necessary control cards are:

Title card - parameter name, TITLE. Any 80 column alphameric list, one card.

Format card - parameter name, FMT. Format of data, 80 columns, one card.

Filter format card - parameter name, FILFMT. Format of filter matrix, 80 columns, one card.

A complete data deck consists of the following:

1. NAMELIST CARD
2. TITLE CARD
3. DATA FORMAT
4. FILTER FORMAT
5. DATA
6. FILTER MATRIX

All computations are based on data from which a linear trend has been removed.

Two examples of output are given in Appendix B. (The title card was blank for both examples.) All major output headings begin on a new page but in Appendix B have been compressed to provide greater ease in use. As can be seen in the first example, there is a considerable amount of intermediate output. This was considered a desirable option as the program can also be used to perform spatial filtering and other types of trend surface analysis by proper design of the filter matrix. In general, the option IPR = 1 or 3 gives the most useful information.

PROPER LIMITATIONS

The program is limited to a 65 x 65 data matrix from which a 30 x 30 autocorrelation matrix can be computed. The filter matrix is restricted to a 9 x 9 set of coefficients. The above dimensions were used for convenience and can be readily changed by altering the dimension of the variables. It appears, however, that the row/column lag shifts of the autocorrelation matrix should never exceed one-third that of the data matrix due to truncation effects in computation.

The linear trend removal routine was purposely written to involve a matrix inversion and thus to allow for incorporation of removal of any form of trend if so desired. This would require changes in the dimension of the variables and increasing the limits of all do loops within that section.

It should be indicated, however, that trends above the first order would generally be treated by the program as higher frequency events. It is, therefore, not necessary to remove higher order trends unless one wished to concentrate study on particular wavelengths.

ACKNOWLEDGEMENTS

The writer acknowledges the advice and many helpful discussions with Professor E. H. T. Whitten, Northwestern University. The writer expresses appreciation to Chevron Oil Field Research Company for aid in preparation of this paper.

REFERENCES

Agterberg, F. P., 1965, The technique of serial correlation applied to continuous series of element concentration values in homogenous rocks: J. Geol., vol. 73, no. 1, pp. 142-154.

Anderson, R. L., 1942, Distribution of the serial correlation coefficient: Annals Math. Stat., vol. 3, pp. 1-13.

Blackman, R. B., and J. W. Tukey, 1959, The measurement of power spectra: Dover Pub. Inc., New York.

Cote, L. J., J. O. Davis, W. Marks, R. J. McGough, E. Mehr, W. J. Pierson, J. F. Ropsek, G. Stephenson, and R. C. Vetter, 1960, The directional spectrum of a wind generated sea as determined from data obtained by the stereo wave observation project, edit. W. J. Pierson, Jr.: Meteorological Papers, New York Univ., College of Eng., vol. 2, no. 6.

Esler, J. E., and F. N. Preston, 1967, Fortran IV Program for the GE 625 to compute the power spectrum of geological surfaces. Computer Contribution 16, State Geol, Surv., Univ. of Kansas, Lawrence.

Grant, F., 1957, A problem in the analysis of geophysical data: Geophysics, vol. 22, pp. 309-344.

Hempkins, W. B., 1965, The applicability of mathematical surfaces to correlation and prediction in Witwatersrand gold mines: Econ. Geol. Res. Unit info circular no. 26, Univ. Witwatersrand, Johannesburg, South Africa.

----------, 1969, Mathematical and statistical models for prediction of ore distribution patterns in mines of the Witwatersrand Basin, South Africa. Ph.d. dissertation, Dept. Geology, Northwestern Univ., Evanston, Illinois.

Horton, C. W., W. B. Hempkins, and A. A. J. Hoffman, 1964, A statistical analysis of some aeromagnetic maps from the northwestern Canadian Shield: Geophysics, vol. 29, no. 4, pp. 582-601.

Horton, C. W., A. A. J. Hoffman, and W. B. Hempkins, 1962, Mathematical analysis of the microstructure of an area of the bottom of Lake Travis: J. Texas Acad. Sci., vol. 14, pp. 331-342.

James, W. R., 1966, The Fourier series model in map analysis: ONR task no. 388-078, Tech. Report no. 1, contract Nonr 1228(36), Dept. of Geol., Northwestern Univ., Evanston, Illinois.

Jenkins, G. M. and Watts, D. G., 1968, Spectral analysis and its applications, Holden-Pay, Inc., San Francisco, Calif.

Krige, D. G., 1965, The estimation and control of ore grades in gold mines. In Pirow, P. C. and D. G. Krige, The use of mathematical statistics and computers for planning and control on the gold mines of the Transvaal and Orange Free State: Eighth Commonwealth Min. and Metall. Congress, Australia.

----------, and H. J. Ueckermann, 1963, Value contours and improved regression techniques for ore reserve valuations: J. So. African Inst. Min. and Metall., vol. 63, pp. 429-452.

Krumbein, W. C., 1966, A comparison of polynomial and Fourier models in map analysis: ONR task no. 388-078, Techn. Report no. 2, Contract Nonr 1228(36), Dept. of Geol., Northwestern Univ., Evanston, Illinois.

----------, 1967, The general linear model in map preparation and analysis: State Geol. Survey, Univ. Kansas, Lawrence, Kansas, Computer Contribution 12, pp. 38-44.

----------, and A. G. Graybill, 1965, An introduction to statistical models in geology: McGraw-Hill Book Co., New York.

Matalas, N. C., 1963, Autocorrelation of rainfall and streamflow minimums: U. S. Geol. Surv. Prof. Paper 434-B.

Whitten, E. H. T., 1965, The general linear equation in prediction of gold content in Witwatersrand rocks, South Africa: J. South African Inst. Min. and Metall., vol. 65, pp. 124-156.

----------, 1967, Quantitative models in the economic evaluation of rock units: illustrated with the Donegal granite and the gold-bearing Witwatersrand conglomerates: Trans. Section B, Inst. of Min. and Metall., vol. 75, pp. B181-B198.

Wiener, N., 1930, Generalized harmonic analysis: Acta Math, vol. 55, pp. 117-258.

----------, 1949, Extrapolation, interpolation, and smoothing of stationary time series: John Wiley and Sons, Inc., New York.

Yule, G. U., 1927, On a method of investigating periodicities in disturbed series with special reference to Wolfer's sunspot numbers: Philos. Trans., vol. A226, p. 267.

APPENDIX A

DATA

The following listing of data is taken from a 13 x 18 array whose coordinates were numbered from an arbitrary origin. The grid spacing was 50 feet. Each card in the data deck contained three items:

U The row coordinates increasing southward down the map.

V The column coordinates increasing eastward across the map.

X The dependent variable, gold, in inch pennyweights (in-dwt = pennyweights gold/ton x reef thickness in inches)

U	V	X
0	16	312
0	17	404
0	18	442
0	19	544
0	20	523
0	21	334
0	22	330
0	23	440
0	24	419
0	25	228
0	26	101
0	27	120
0	28	145
0	29	109
0	30	121
0	31	130
0	32	96
0	33	91
1	16	321
1	17	510
1	18	514
1	19	453
1	20	470
1	21	394
1	22	296
1	23	319
1	24	355
1	25	222
1	26	106
1	27	114
1	28	154
1	29	142
1	30	139
1	31	110
1	32	94
1	33	89
2	16	183
2	17	374
2	18	412
2	19	351
2	20	430
2	21	406
2	22	350
2	23	282
2	24	253
2	25	240
2	26	160
2	27	157
2	28	181
2	29	206
2	30	151
2	31	102
2	32	104
2	33	99
3	16	162
3	17	246
3	18	265
3	19	347
3	20	462
3	21	448
3	22	401
3	23	315
3	24	246
3	25	275
3	26	301
3	27	268
3	28	238
3	29	185
3	30	119
3	31	140
3	32	114
3	33	109
4	16	178
4	17	193
4	18	215
4	19	294
4	20	448
4	21	470
4	22	375
4	23	324
4	24	280
4	25	291
4	26	327
4	27	348
4	28	292
4	29	207
4	30	160
4	31	120
4	32	98
4	33	93
5	16	162
5	17	258
5	18	295
5	19	346
5	20	417
5	21	405
5	22	350
5	23	364
5	24	363
5	25	292
5	26	241
5	27	266
5	28	289
5	29	296
5	30	261
5	31	163
5	32	104
5	33	99

U	V	X
6	16	249
6	17	394
6	18	352
6	19	330
6	20	388
6	21	366
6	22	358
6	23	414
6	24	406
6	25	294
6	26	269
6	27	314
6	28	336
6	29	336
6	30	284
6	31	287
6	32	223
6	33	136
7	16	285
7	17	383
7	18	336
7	19	125
7	20	214
7	21	346
7	22	364
7	23	378
7	24	433
7	25	425
7	26	433
7	27	426
7	28	333
7	29	336
7	30	342
7	31	362
7	32	322
7	33	279
8	16	256
8	17	252
8	18	192
8	19	30
8	20	160
8	21	325
8	22	270
8	23	290
8	24	408
8	25	476
8	26	519
8	27	453
8	28	299
8	29	310
8	30	440
8	31	489
8	32	445
8	33	356
9	16	283
9	17	236
9	18	150
9	19	77
9	20	149
9	21	262
9	22	224
9	23	262
9	24	358
9	25	407
9	26	437
9	27	423
9	28	291
9	29	293
9	30	426
9	31	521
9	32	468
9	33	385
10	16	373
10	17	342
10	18	264
10	19	221
10	20	259
10	21	316
10	22	312
10	23	320
10	24	376
10	25	356
10	26	464
10	27	538
10	28	409
10	29	400
10	30	471
10	31	456
10	32	438
10	33	426
11	16	338
11	17	384
11	18	390
11	19	371
11	20	382
11	21	435
11	22	412
11	23	337
11	24	313
11	25	276
11	26	439
11	27	648
11	28	561
11	29	474
11	30	468
11	31	395
11	32	404
11	33	501
12	16	168
12	17	303
12	18	404
12	19	395
12	20	350
12	21	358
12	22	381
12	23	335
12	24	294
12	25	312
12	26	473
12	27	556
12	28	498
12	29	410
12	30	283
12	31	222
12	32	291
12	33	488

+1.0

APPENDIX B

Program Listing and Sample Output

```
C     PRCGRAM GECCOVR
C
C PROGRAM GECCCVR CCMPUTES A MAXIMUM 30 X 30LAG TWC-DIMENSIONAL AUTOCOVARIANCE
C CR SERIAL CCRRELATICN COEFFICIENT ARRAY FOR A MAXIMUM OF 65 X 65 DATA
C POINTS.  A 95 ANC 99 PERCENT CCNFICENCE LEVEL IS COMPUTED TO TEST THE NULL
C HYPOTHESIS THAT THE DATA IS RANDOMLY DISTRIBUTED.
C THE EXPECTEC AUTOCORRELATION COEFFICIENT, C(I,J), I.NE.J=0
C
C PROGRAMMED FOR THE CDC 340C AT NORTHWESTERN UNIVERSITY,
C DECEMBER, 1966 BY W. E. HEMPKINS
C
C  IPR=0  PRINT ALL OUTPUT
C  IPR=1  SUPPRESS INTERMEDIATE PRINTING
C  IPR=2  SUPPRESS CCNF BUT ALLOW INTERMEDIATE PRINTING
C  IPR=3  SUPPRESS INTERMEDIATE PRINTING BUT DO CCNF
C  ICLAG = COLUMN LAG DISTANCE IN TERMS OF SAMPLING INTERVAL
C  IRLAG = ROW LAG DISTANCE IN TERMS OF SAMPLING INTERVAL
C  NCOL  = NUMBER OF COLUMNS OF DATA
C  NROW  = NUMEER OF RCWS OF DATA
C  NFILC = NUMBER OF CCLUMNS IN FILTER MATRIX
C  NFILR = NUMBER OF ROWS IN FILTER MATRIX
C  NCLAG = NUMBER OF CCLUMN LAGS
C  NRLAG = NUMBER OF ROW LAGS
C  IREAD=0 READ CNE VARIABLE AT A TIME FOR NROW VALUES
C       =1 READ ALL VARIABLES FROM SAME CARD
C
      DIMENSICN X(65,65),C(30,30),CC(30,30),P(30,30),PP(30,30),F(9,9),
     1FMT(20),FILFMT(20),TITLE(20)
      DIMENSION D(30,30), Z(30,30), DD(30,30), ZZ(30,30)
      DIMENSICN COE(3),XM(3,3),YV(3)
      DIMENSICN EM(3)
      REAL*8 XM,YV,COE
      COMMON X
C FORMATS-- STATEMENTS 1000-1999 ARE RESERVEC FOR FORMATS
C
      NAMELIST/CCVR/NROW,NCOL ,NFILR,NFILC,NRLAG,NCLAG,IRLAG,ICLAG,
     1IPR,IREAD
C
C  DEFAULTS
      ICLAG=1
      IRLAG=1
      IPR  =1
      IREAD=C
      NFILC=1
      NFILR=1
      NCLAG=1
      NRLAG=1
C
  100 READ(5,CCVR,END=300)
      READ(5,1000)TITLE
 1000 FORMAT (20A4)
      READ 1000,  FMT
      PRINT 1001,  FMT
 1001 FORMAT (1H1, ' DATA INPUT FORMAT IS ' 20A4//)
```

```
      REAC 1000, FILFMT
      PRINT 1CC2, FILFMT
 1002 FORMAT (' FILTER INPUT FORMAT IS  ' 20A4//)
C
      PRINT 1CC4, NRCW,NCCL,NFILR,NFILC,NRLAG,NCLAG,     IRLAG,ICLAG
 1004 FORMAT (I5,25H = NUMBER OF ROWS OF DATA/I5,28H = NUMBER OF COLUMNS
     1 CF CATA/I5,27H = NUMBER OF ROWS IN FILTER/I5,3CH = NUMBER OF COLU
     2MNS IN FILTER/I5,43H = NUMBER CF RCW LAGS, LR=1 MEANS ZERO LAGS/I5
     3,46H = NUMBER OF COLUMN LAGS, LC=1 MEANS ZERC LAGS /,I5,
     5      ' = NUMBER OF SAMPLE INTERVALS IN ONE ROW LAG ' /
     6 I5, ' = NUMBER CF SAMPLE INTERVALS IN CNE CCLUMN LAG '//)
      IF (IREAD.EC.1)GO TO 1C5
      DC 101 I=1,NRCW
  101 READ  FMT, (X(I,J), J=1,NCCL)
      GC TC 107
  1C5 DO 103 J=1,NCCL
  103 REAC  FMT, (X(I,J), I=1,NRCW)
  107 PRINT 1005
 1C05 FORMAT (1H1, '  CRIGINAL CATA MATRIX ' //)
      DO 104 I=1,NROW
  104 PRINT  400, (X(I,J),J=1,NCOL)
  40C FORMAT(1H ,12F1C.3)
      DO 102 I=1,NFILR
  102 REAC FILFMT,(F(I,J),J=1,NFILC)
C
C COMPUTE MEAN,VARIANCE AND STANDARD DEVIATION
      A=0.0
      DO 11C I=1,NRCW
      DO 110 J=1,NCOL
  110 A=A+X(I,J)
      A=A/(NRCW*NCOL)
      CCRRSC=0.0
      DC 112 I=1,NRCW
      DO 112 J=1,NCOL
  112 CCRRSQ=CCRRSQ+(X(I,J)-A)**2
      VAR=CCRRSC/(NCCL*NROW-1)
      STDEV=VAR**C.5
      PRINT 1007, A,CORRSQ,VAR,STDEV
 1007 FORMAT (////' AVERAGE CF CRIGINAL CATA ='F15.6/
     1' UNCORRECTED SUMS OF SQUARES = ' F15.6/
     2 ' VARIANCE = ' F15.6  /
     3 ' STANDARD DEVIATICN = ' F15.6 )
C
C REMCVE LINEAR TRENC
C
      DO 120 I=1,3
      YV(I)=0.0
      DC 120 J=1,3
      XM(I,J)=C.C
  120 CCE(I)=0.0
      DO 13C I=1,NRCW
      U=I
      DC 130 J=1,NCOL
      V=J
```

```
      XM(1,1)=XM(1,1)+1.0
      XM(1,2)=XM(1,2)+U
      XM(1,3)=XM(1,3)+V
      XM(2,1)=XM(1,2)
      XM(2,2)=XM(2,2)+U**2
      XM(2,3)=XM(2,3)+U*V
      XM(3,1)=XM(1,3)
      XM(3,2)=XM(2,3)
      XM(3,3)=XM(3,3)+V**2
      YV(1)=X(I,J)+YV(1)
      YV(2)=YV(2)+X(I,J)*U
  130 YV(3)=YV(3)+X(I,J)*V
      DO 144 K=1,3
      DIV=XM(K,K)
      XM(K,K)=1.0
      DO 141 J=1,3
  141 XM(K,J)=XM(K,J)/DIV
      DO 144 I=1,3
      IF(I-K) 142,144,142
  142 DIV=XM(I,K)
      XM(I,K)=0.0
      DO 143 J=1,3
  143 XM(I,J)=XM(I,J)-DIV*XM(K,J)
  144 CONTINUE
      DO 148 I=1,3
      DO 148 J=1,3
  148 COE(I)=COE(I)+XM(I,J)*YV(J)
      DO 149 I=1,NROW
      EYE=I
      DO 149 J=1,NCOL
      AJAY=J
  149 X(I,J)=X(I,J)-(COE(1)+COE(2)*EYE+COE(3)*AJAY)
  121 FORMAT (///'  THE COEFFICIENTS OF THE REGRESSION PLANE OF THE DATA
     1 ARE COMPUTED AS',// 5X, E15.8,5X,E15.8,'  U ',5X,E15.8,'  V ')
      PRINT 121, COE(1),COE(2),COE(3)
  122 FORMAT (1H1,'  LEVELLED DATA'//)
      PRINT 122
      DO 123 I=1,NROW
  123 PRINT  400, (X(I,J), J=1,NCOL)
C FILTER DATA AND PRINT
      MA=1+(NFILR/2)
      MB=NROW-(NFILR/2)
      NA=1+(NFILC/2)
      NB=NCOL-(NFILC/2)
      DO 150 I=MA,MB
      DO 150 J=NA,NB
      T=0.0
      DO 151 K=1,NFILR
      KK=I+K-(NFILR/2)-1
      DO 151 L=1,NFILC
      LL=J+L-(NFILC/2)-1
  151 T=T+F(K,L)*X(KK,LL)
  150 X(I,J)=T
      IF(IPR.EQ.1.OR.IPR.EQ.3)GO TO 153
```

```
      PRINT 1008
 1CC8 FURMAT (1H1, '  FILTEREC CATA MATRIX ' //)
      DO 152 I=1,NROW
  152 PRINT  400, (X(I,J), J=1,NCOL)
C POSITIVE SHIFT AUTOCCVARIANCE
  153 CC 161 I=1,NRLAG
      U=NRCW-1-I+2
      NU=NROW-I+1
      CC 161 J=1,NCLAG
      V=NCCL-1-J+2
      NV=NCOL-J+1
      SUM=0.0
      DC 160 K=1,NU,IRLAG
      DO 160 L=1,NV,ICLAG
      KK=K+I-1
      LL=L+J-1
  160 SUM=SUM +X(K,L)*X(KK,LL)
  161 C(I,J)=SUM/(U*V)
      IF(IPR.EG.1.OR.IPR.EG.3)GC TO 163
      PRINT 1009
 1009 FCRMAT (1H2, '  PCSITIVE SHIFT AUTOCOVARIANCE MATRIX ' //)
      DO 162 I=1,NRLAG
  162 PRINT 1010, (C(I,J), J=1,NCLAG)
 101C FCRMAT (1X,10(F10.4,1X))
C NEGATIVE SHIFT AUTOCOVARIANCE
  163 DO 171 K=1,NRLAG
      KK=NROW-K+1
      DO 171 L=1,NCLAG
      KL=NCLAG-L+1
      LL=NCOL-L+1
      SUM=0.0
      DO 170 I=1,KK,IRLAG
      IU=I+K-1
      DO 170 J=1,LL,ICLAG
      JV=J+L-1
  170 SUM=SUM+X(IU,J)*X(I,JV)
  171 CC(K,KL)=SUM/(KK*LL)
      IF(IPR.EC.1.OR.IPR.EC.3)GO TO 173
      PRINT 1011
 1011 FCRMAT (1HO, '  NEGATIVE SHIFT AUTOCOVARIANCE MATRIX ' //)
      DO 172 I=1, NRLAG
  172 PRINT 1C1C, (CC(I,J), J=1,NCLAG)
C NORMALIZE AUTCCCVARIANCE MATRIX
  173 CNORM=C(1,1)
      DO 18C I=1,NRLAG
      DC 180 J=1,NCLAG
      C(I,J)=C(I,J)/CNORM
  180 CC(I,J)=CC(I,J)/CNORM
      PRINT 1012
 1012 FURMAT (1H1, ' PCSITIVE SHIFT AUTCCCRRELATICN MATRIX ' //)
      DC 181 I=1,NRLAG
  181 PRINT 1010, (C(I,J), J=1,NCLAG)
      PRINT 1013
 1013 FORMAT (1HO, ' NEGATIVE SHIFT AUTOCORRELATICN MATRIX ' //)
```

```
      DO 182 I=1,NRLAG
  182 PRINT 1010, (CC(I,J), J=1,NCLAG)
      PRINT 1022
 1022 FORMAT (1H1, ' MAP OF AUTOCORRELATION MATRIX ' //)
      CALL MAP(C,CC,NRLAG,NCLAG)
      IF(IPR.EQ.1.OR.IPR.EQ.2)GO TO 215
      CALL CONF(C,CC,NRLAG,NCLAG,NROW,NCOL)
  215 PRINT 1040
 1040 FORMAT (///' THIS PROBLEM IS FINISHED ')
      GO TO 100
  300 RETURN
      END
      SUBROUTINE CONF(C,CC,LR,LC,M,N)
      DIMENSION C(30,30),CC(30,30),P(30,30),PP(30,30),D(30,30),DD(30,30)
     1          ,Z(30,30),ZZ(30,30)
C COMPUTE CONFIDENCE TEST VALUES AND TEST AUTOCORRELATION MATRIX
      T95=1.960
      T99=2.576
      CHECK = M*N
      IF (CHECK .LT.120) GO TO 183
      GO TO 184
  183 CALL TLIST (CHECK,T95,T99)
  184 T=T95
      TLEVEL=95.0
  200 DO 201 I=1,LR
      DO 201 J=1,LC
      P(I,J)=(-1.0+(T*((M-I)*(N-J)-2)**0.5))/((M-J)*(N-I)-1)
      K=LC-J+1
  201 PP(I,K)=(-1.0-(T*((M-I)*(N-K)-2))**0.5)/((M-K)*(N-I)-1)
      DO 213 I=1,LR
      DO 213 J=1,LC
      IF (P(I,J) .LT. C(I,J)) GO TO 202
      D(I,J)=0.0
      GO TO 203
  202 D(I,J)=C(I,J)
  203 IF (PP(I,J) .GT. C(I,J)) GO TO 205
  204 DD(I,J)=0.0
      GO TO 207
  205 DD(I,J)= C(I,J)
  207 IF (P(I,J) .LT. CC(I,J)) GO TO 209
  208 Z(I,J)=0.0
      GO TO 210
  209 Z(I,J)=CC(I,J)
  210 IF (PP(I,J) .GT. CC(I,J)) GO TO 212
  211 ZZ(I,J)=0.0
      GO TO 213
  212 ZZ(I,J)=CC(I,J)
  213 CONTINUE
      PRINT 1018,TLEVEL
 1018 FORMAT (1H1, ' UPPER ' F4.0, ' CONFIDENCE SURFACE, SOUTHEAST QUADR
     1ANT OF A SYMMETRICAL FUNCTION ' //)
      DO 216 I=1,LR
  216 PRINT 1010, (P(I,J), J=1,LC)
 1010 FORMAT (1X,10(F10.4,1X))
```

```
      PRINT 1019, TLEVEL
1019 FORMAT (1H0, ' LOWER ' F4.0, ' CONFIDENCE SURFACE, SOUTHEAST QUADR
    1ANT OF A SYMMETRICAL FUNCTION ' //)
      DO 217 I=1,LR
 217 PRINT 1010, (PP(I,J), J=1,LC)
      PRINT 1014, TLEVEL
1014 FORMAT (1H1, '  SIGNIFICANT UPPER AUTOCORRELATION VALUES AT ' F4.0
    1,'PERCENT CONFIDENCE LEVEL, POSITIVE SHIFT '//)
      DO 218 I=1,LR
 218 PRINT 1010, (D(I,J), J=1,LC)
      PRINT 1015, TLEVEL
1015 FORMAT (1H0,'  SIGNIFICANT LOWER AUTOCORRELATION VALUES AT ' F4.0
    1,'PERCENT CONFIDENCE LEVEL, POSITIVE SHIFT '//)
      DO 219 I=1,LR
 219 PRINT 1010, (DD(I,J), J=1,LC)
      PRINT 1016,TLEVEL
1016 FORMAT (1H1, '  SIGNIFICANT UPPER AUTOCORRELATION VALUES AT ' F4.0
    1,'PERCENT CONFIDENCE LEVEL, NEGATIVE SHIFT '//)
      DO 220 I=1,LR
 220 PRINT 1010, (Z(I,J), J=1,LC)
      PRINT 1017, TLEVEL
1017 FORMAT (1H0,'  SIGNIFICANT LOWER AUTOCORRELATION VALUES AT ' F4.0
    1,'PERCENT CONFIDENCE LEVEL,NEGATIVE  SHIFT '//)
      DO 221 I=1,LR
 221 PRINT 1010, (ZZ(I,J) , J=1,LC)
      PRINT 1030, TLEVEL
1030 FORMAT (1H1, ' MAP OF SIGNIFICANT POSITIVE AUTOCORRELATION COEFFIC
    1IENTS AT ' F3.0, ' PERCENT PROBABILITY LEVEL '//)
      CALL MAP (D,Z,LR,LC)
1031 FORMAT (1H1, ' MAP OF SIGNIFICANT NEGATIVE AUTOCORRELATION COEFFIC
    1IENTS AT ' F3.0, ' PERCENT PROBABILITY LEVEL '//)
      PRINT 1031, TLEVEL
      CALL MAP (DD,ZZ,LR,LC)
      IF (T-T95) 215,214,215
 214 T=T99
      TLEVEL=99.0
      GO TO 200
 215 RETURN
      END
      SUBROUTINE MAP (A,B,LR,LC)
      DIMENSION A(30,30),B(30,30),IVAL(65,65),ALINE(135),HOL(21)
      COMMON IVAL
      INTEGER HOL
      DATA BAR/1HI/,DASH/1H-/
      DATA HOL/2H-X,2H-9,2H-8,2H-7,2H-6,2H-5,2H-4,2H-3,2H-2,2H-1,2H 0,2H
     1+1,2H+2,2H+3,2H+4,2H+5,2H+6,2H+7,2H+8,2H+9,2H+X/
1021 FORMAT (1X,27(A2,3X)/4X)
1023 FORMAT (1X,134A1/4X)
      KEEP=LR
      KEPT=LC
      IF(LR.GT.12) LR=12
      IF(LC.GT.12)LC=12
      NLR=LR*2-1
      NLC=LC*2-1
```

```
      LRC=NLC*5+11
      DO 506 I=1,128
  506 ALINE (I) = DASH
      PRINT 1050
 1050 FORMAT (/' COEFFICIENTS ARE MULTIPLIED BY 10'/ ' AN X INDICATES TH
     1E VALUE OF +1.0 OR -1.0 COEFFICIENTS '//)
      DO 501 I=1,LR
      II=LR+1-I
      DO 501 J=1,LC
      JJ=LC+1-J
  501 IVAL(I,J)=A(II,JJ)*10.0
      LCN=LC-1
      DO 502 I=1,LR
      II=LR+1-I
      DO 502 J=1,LC
      JJ=LC+J-1
      JK=LC-J+1
  502 IVAL(I,JJ)=B(II,JK)*10.0
      DO 503 I=2,LR
      II=I+LR-1
      DO 503 J=1,LC
  503 IVAL(II,J)=B(I,J)*10.0
      DO 504 I=2,LR
      II=I+LR-1
      DO 504 J=2,LC
      JJ=J+LC-1
  504 IVAL(II,JJ)=A(I,J)*10.0
      DO 510 I=1,NLR
      DO 510 J=1,NLC
      K=IVAL(I,J)+11
  510 IVAL(I,J)=HOL(K)
      IF (NLR .GT. 25) GO TO 511
      IA=1
      IB=NLR
      GO TO 512
  511 RRM = NLR
      IDIFF= ((RRM-25.)/2.) + .5
      IA=IDIFF
      IB=IDIFF+25
  512 IF (NLC .GT.25) GO TO 513
      IC=1
      ID=NLC
      GO TO 514
  513 CNL=NLC
      IDIFF=((CNL-25.)/2.) + .5
      LRC=LRC-IDIFF*5
      IC=IDIFF
      ID=IDIFF+25
  514 IIR=LRC-10*IC+5
      PRINT 1023, (ALINE(I),I=1,IIR)
      DO 505 I=IA,IB
  505 PRINT 1021, (BAR, (IVAL(I,J), J=IC,ID),BAR)
      PRINT 1023, (ALINE(I),I=1,IIR)
      LR=KEEP
```

```
      LC=KEPT
      RETURN
      END
      SUBROUTINE TLIST (CHECK,A,B)
      DIMENSION T1(4),T2(4),TOTAL(4)
      DATA T1/1.697,1.684,1.671,1.658/
      DATA T2/2.457,2.423,2.390,2.358/
      DATA TOTAL/30.,40.,60.,120./
      DO 2 I=1,4
      IF (CHECK .GT. TOTAL (I)) GO TO 2
      A=T1(I)
      B=T2(I)
      GO TO 3
    2 CONTINUE
    3 RETURN
      END
```

DATA INPUT FORMAT IS (20X,F3.0)

FILTER INPUT FORMAT IS (5F4.0)

13 = NUMBER OF ROWS OF DATA
18 = NUMBER OF COLUMNS OF DATA
1 = NUMBER OF ROWS IN FILTER
1 = NUMBER OF COLUMNS IN FILTER
10 = NUMBER OF ROW LAGS, LR=1 MEANS ZERO LAGS
10 = NUMBER OF COLUMN LAGS, LC=1 MEANS ZERO LAGS
1 = NUMBER OF SAMPLE INTERVALS IN ONE ROW LAG
1 = NUMBER OF SAMPLE INTERVALS IN ONE COLUMN LAG

ORIGINAL DATA MATRIX

312.000	404.000	442.000	544.000	523.000	334.000	330.000	440.000	419.000	228.000	101.000	120.000
145.000	109.000	121.000	130.000	96.000	91.000						
321.000	510.000	514.000	453.000	470.000	394.000	296.000	319.000	355.000	222.000	106.000	114.000
154.000	142.000	139.000	110.000	94.000	89.000						
183.000	374.000	412.000	351.000	430.000	406.000	350.000	282.000	253.000	240.000	160.000	157.000
181.000	206.000	151.000	102.000	104.000	99.000						
182.000	246.000	285.000	347.000	482.000	448.000	401.000	315.000	246.000	275.000	301.000	268.000
238.000	185.000	119.000	140.000	114.000	109.000						
178.000	193.000	215.000	294.000	448.000	470.000	375.000	324.000	280.000	291.000	327.000	348.000
292.000	207.000	160.000	120.000	98.000	93.000						
162.000	258.000	295.000	346.000	417.000	405.000	350.000	364.000	363.000	292.000	241.000	266.000
289.000	296.000	261.000	163.000	104.000	99.000						
249.000	394.000	352.000	330.000	388.000	366.000	358.000	414.000	406.000	294.000	269.000	314.000
336.000	336.000	284.000	287.000	223.000	136.000						
285.000	383.000	336.000	125.000	214.000	346.000	364.000	378.000	433.000	425.000	433.000	426.000
333.000	336.000	342.000	362.000	322.000	279.000						
256.000	252.000	192.000	30.000	160.000	325.000	270.000	290.000	408.000	476.000	519.000	453.000
299.000	310.000	440.000	489.000	445.000	396.000						
283.000	236.000	150.000	77.000	149.000	262.000	224.000	262.000	358.000	407.000	437.000	423.000
291.000	293.000	426.000	521.000	468.000	385.000						
373.000	342.000	264.000	221.000	259.000	316.000	312.000	320.000	376.000	356.000	464.000	538.000
409.000	400.000	471.000	456.000	438.000	426.000						
338.000	384.000	390.000	371.000	382.000	435.000	412.000	337.000	313.000	276.000	439.000	648.000
561.000	474.000	468.000	395.000	404.000	501.000						
168.000	303.000	404.000	395.000	350.000	358.000	381.000	335.000	294.000	312.000	473.000	556.000
498.000	410.000	283.000	222.000	291.000	488.000						

AVERAGE OF ORIGINAL DATA = 311.226318
UNCORRECTED SUMS OF SQUARES = 3411035.000000
VARIANCE = 14639.652344
STANDARD DEVIATION = 120.994476

THE COEFFICIENTS OF THE REGRESSION PLANE OF THE DATA ARE COMPUTED AS

C.260868780 03   0.115719170 02 U   -[illegible] 01 V

LEVELLED DATA

42.680	138.201	179.721	285.242	267.762	82.283	81.803	195.324	177.845	-9.635	-133.114	-110.593
-82.073	-114.552	-99.032	-86.511	-116.990	-118.470						
39.708	232.229	239.749	182.270	202.790	130.311	35.832	62.352	101.873	-27.607	-140.086	-128.565
-85.045	-93.524	-93.004	-118.483	-130.962	-132.442						
-110.264	84.257	125.777	68.298	150.818	130.339	77.860	13.380	-12.099	-21.579	-98.058	-97.537
-70.017	-41.456	-92.976	-138.455	-132.934	-134.414						
-123.236	-55.715	-13.195	52.326	190.847	160.367	116.888	34.408	-31.071	1.450	30.970	1.491
-24.989	-74.468	-136.947	-112.427	-134.906	-136.386						
-139.208	-120.687	-95.167	-12.646	144.875	170.395	78.916	31.436	-9.043	5.478	44.998	69.519
17.039	-64.440	-107.919	-144.399	-162.878	-164.358						
-167.180	-67.659	-27.138	27.382	101.903	93.423	41.944	59.465	61.985	-5.494	-52.974	-24.453
2.068	12.588	-18.851	-113.371	-168.850	-170.329						
-92.152	56.369	17.890	-0.590	60.931	42.451	37.972	97.493	93.013	-15.466	-36.946	11.575
37.096	40.616	-7.863	-1.343	-61.822	-145.301						
-68.124	33.397	-10.082	-217.562	-125.041	10.479	32.000	49.521	108.041	103.562	115.082	111.603
22.124	28.644	38.165	61.685	25.206	-14.273						
-109.095	-109.575	-166.054	-324.533	-191.013	-22.492	-73.972	-50.451	71.069	142.590	189.111	126.631
-23.848	-9.328	124.193	176.714	136.234	50.755						
-94.067	-137.547	-220.026	-289.505	-213.985	-97.464	-131.944	-90.423	9.097	61.618	95.139	84.659
-43.820	-38.300	98.221	156.742	147.262	67.783						
-16.039	-43.519	-117.998	-157.477	-115.957	-55.436	-55.916	-44.395	15.126	-1.354	110.167	187.687
62.208	56.729	131.249	115.770	105.290	96.811						
-63.011	-13.491	-3.970	-19.449	-4.929	51.592	32.112	-39.367	-59.846	-93.326	73.195	285.715
202.236	118.757	116.277	46.798	59.318	159.839						
-244.983	-106.462	-1.942	-7.421	-48.901	-37.380	-10.859	-53.339	-90.818	-69.298	95.223	181.743
127.264	42.785	-80.695	-138.174	-65.653	134.867						

FILTERED DATA MATRIX

42.680	138.201	179.721	285.242	267.762	82.283	81.803	195.324	177.845	-9.635	-133.114	-110.593
-82.073	-114.552	-99.032	-86.511	-116.990	-118.470						
39.708	232.229	239.749	182.270	202.790	130.311	35.832	62.352	101.873	-27.607	-140.086	-128.565
-85.045	-93.524	-93.004	-118.483	-130.962	-132.442						
-110.264	84.257	125.777	68.298	150.818	130.339	77.860	13.380	-12.099	-21.579	-98.058	-97.537
-70.017	-41.456	-92.976	-138.455	-132.934	-134.414						
-123.236	-55.715	-13.195	52.326	190.847	160.367	116.888	34.408	-31.071	1.450	30.970	1.491
-24.989	-74.468	-136.947	-112.427	-134.906	-136.386						
-139.208	-120.687	-95.167	-12.646	144.875	170.395	78.916	31.436	-9.043	5.478	44.998	69.519
17.039	-64.440	-107.919	-144.399	-162.878	-164.358						
-167.180	-67.659	-27.138	27.382	101.903	93.423	41.944	59.465	61.985	-5.494	-52.974	-24.453
2.068	12.588	-18.891	-113.371	-168.850	-170.329						
-92.152	56.369	17.890	-0.590	60.931	42.451	37.972	97.493	93.013	-15.466	-36.946	11.575
37.096	40.616	-7.863	-1.343	-61.822	-145.301						
-68.124	33.397	-10.082	-217.562	-125.041	10.479	32.000	49.521	108.041	103.562	115.082	111.603
22.124	28.644	38.165	61.685	25.206	-14.273						
-109.095	-109.575	-166.054	-324.533	-191.013	-22.492	-73.972	-50.451	71.069	142.590	189.111	126.631
-23.848	-9.328	124.193	176.714	136.234	50.755						
-94.067	-137.547	-220.026	-289.505	-213.985	-97.464	-131.944	-90.423	9.097	61.618	95.139	84.659
-43.820	-38.300	98.221	156.742	147.262	67.783						
-16.039	-43.519	-117.998	-157.477	-115.957	-55.436	-55.916	-44.395	15.126	-1.354	110.167	187.687
62.208	56.729	131.249	115.770	105.290	96.811						
-63.011	-13.491	-3.970	-19.449	-4.929	51.592	32.112	-39.367	-59.846	-93.326	73.195	285.715
202.236	118.757	116.277	46.798	59.318	159.839						
-244.983	-106.462	-1.942	-7.421	-48.901	-37.380	-10.859	-53.339	-90.818	-69.298	95.223	181.743
127.264	42.785	-80.695	-138.174	-65.653	134.867						

POSITIVE SHIFT AUTOCOVARIANCE MATRIX

12236.9297	9425.1797	5609.5000	3578.5115	1931.4419	1021.3086	239.8517	-1990.5938	-4580.1250	-5934.6836
9299.9023	7953.9922	5532.1875	4005.4089	2307.3271	1286.9932	502.4666	-1807.8726	-4183.4453	-5450.2031
5022.9336	5613.2969	5668.1133	5189.6055	3032.2930	1325.2888	640.7727	-1384.5737	-3541.9526	-4530.2344
2427.2502	4197.3320	5762.6711	6222.0039	4265.4766	2445.4873	1972.7083	-87.1089	-2579.4785	-3479.8159
670.9695	2495.1372	4327.6172	5632.0313	5037.9648	3948.6270	3410.8523	934.4272	-1994.5193	-2123.0122
-890.0632	146.2354	1400.7866	3475.8223	4620.4609	4451.0508	3978.9082	1812.9146	-581.7363	56.9954
-3383.3174	-2834.7520	-1716.6765	994.1855	3022.9258	3744.8523	4539.6055	4149.5352	2926.4275	2987.6279
-6096.6328	-5182.5859	-3742.8391	-1532.7813	326.6726	2172.5222	5272.3594	7128.2930	6304.3516	4949.4922
-7813.6016	-6664.5469	-5466.5922	-4557.6680	-3281.6436	-584.5852	4479.3086	8330.8242	7911.7109	5916.3672
-7790.8711	-7494.1406	-6522.9336	-5361.2109	-4064.9263	-1950.2283	2588.9231	6986.5547	8246.4258	7953.3711

NEGATIVE SHIFT AUTOCOVARIANCE MATRIX

-5934.6836	-4580.1250	-1990.5938	239.8517	1021.3086	1931.4419	3578.5115	5609.5000	9425.1797	12236.9297
-5676.9492	-4958.9688	-2834.5814	-951.1748	-253.8870	797.0156	2743.9412	4419.0781	6929.4102	9299.9023
-4209.5625	-4574.2852	-3898.8914	-2617.8384	-1404.5549	-36.0454	1453.9783	1939.9727	2918.8945	5022.9336
-2489.2402	-3756.7456	-4282.0117	-3590.0171	-2023.1038	-441.0293	366.8081	-418.5972	-125.7928	2427.2502
-1757.4575	-3198.1021	-4023.5825	-4160.9961	-3160.6592	-2035.5291	-1596.4551	-2422.2122	-1966.8740	670.9695
-542.8633	-1996.9351	-3151.5837	-4359.2930	-4235.5234	-3814.5569	-3503.9753	-3738.2910	-2988.6979	-890.0632
2120.2112	516.1577	-1311.2417	-3656.8340	-5023.8125	-5407.0703	-5032.2930	-4989.8008	-4719.6875	-3383.3174
5019.0781	3225.7593	777.8435	-2802.0737	-5589.5977	-6773.4883	-6707.2617	-6815.4492	-7003.5625	-6096.6328
6590.7031	5042.9141	1686.3555	-2844.8228	-5984.4141	-7411.4141	-7675.0352	-8061.3477	-8459.8320	-7813.6016
6074.7695	5307.2305	2011.4290	-2988.9517	-6060.1211	-7324.2031	-7302.2578	-7587.7578	-8026.0234	-7790.8711

POSITIVE SHIFT AUTOCORRELATION MATRIX

1.0000	0.7702	0.4584	0.2924	0.1578	0.0835	0.0196	-0.1627	-0.3743	-0.4850
0.7600	0.6500	0.4521	0.3273	0.1886	0.1052	0.0411	-0.1477	-0.3419	-0.4454
0.4105	0.4587	0.4632	0.4241	0.2478	0.1083	0.0524	-0.1131	-0.2894	-0.3702
0.1984	0.3430	0.4709	0.5085	0.3486	0.1998	0.1612	-0.0071	-0.2108	-0.2844
0.0548	0.2039	0.3537	0.4602	0.4117	0.3227	0.2787	0.0764	-0.1630	-0.1735
-0.0727	0.0120	0.1145	0.2840	0.3776	0.3637	0.3252	0.1482	-0.0475	0.0047
-0.2765	-0.2317	-0.1403	0.0812	0.2470	0.3060	0.3710	0.3391	0.2391	0.2441
-0.4982	-0.4235	-0.3059	-0.1253	0.0267	0.1775	0.4309	0.5825	0.5152	0.4045
-0.6385	-0.5446	-0.4468	-0.3725	-0.2682	-0.0478	0.3660	0.6808	0.6465	0.4835
-0.6367	-0.6124	-0.5331	-0.4381	-0.3322	-0.1594	0.2116	0.5709	0.6739	0.6499

NEGATIVE SHIFT AUTOCORRELATION MATRIX

-0.4850	-0.3743	-0.1627	0.0196	0.0835	0.1578	0.2924	0.4584	0.7702	1.0000
-0.4639	-0.4052	-0.2317	-0.0777	-0.0207	0.0651	0.2242	0.3611	0.5663	0.7600
-0.3440	-0.3738	-0.3186	-0.2139	-0.1148	-0.0029	0.1188	0.1585	0.2385	0.4105
-0.2034	-0.3070	-0.3499	-0.2934	-0.1653	-0.0360	0.0300	-0.0342	-0.0103	0.1984
-0.1436	-0.2613	-0.3288	-0.3400	-0.2583	-0.1663	-0.1305	-0.1979	-0.1607	0.0548
-0.0444	-0.1632	-0.2575	-0.3562	-0.3461	-0.3117	-0.2863	-0.3055	-0.2443	-0.0727
0.1733	0.0422	-0.1072	-0.3021	-0.4105	-0.4419	-0.4112	-0.4078	-0.3857	-0.2765
0.4102	0.2636	0.0636	-0.2290	-0.4568	-0.5535	-0.5481	-0.5570	-0.5723	-0.4982
0.5386	0.4121	0.1378	-0.2325	-0.4890	-0.6057	-0.6272	-0.6588	-0.6913	-0.6385
0.4964	0.4337	0.1644	-0.2443	-0.4952	-0.5985	-0.5967	-0.6201	-0.6559	-0.6367

MAP CF AUTOCORRELATION MATRIX

COEFFICIENTS ARE MULTIPLIED BY 10
AN X INDICATES THE VALUE OF +1.0 OR -1.0 COEFFICIENTS

I	+6	+6	+5	+2	-1	-3	-4	-5	-6	-6	-6	-6	-5	-5	-4	-2	+1	+4	+4	I
I	+4	+6	+6	+3	0	-2	-3	-4	-5	-6	-6	-6	-6	-6	-4	-2	+1	+4	+5	I
I	+4	+5	+5	+4	+1	0	-1	-3	-4	-4	-5	-5	-5	-5	-4	-2	0	+2	+4	I
I	+2	+2	+3	+3	+3	+2	0	-1	-2	-2	-3	-4	-4	-4	-4	-3	-1	0	+1	I
I	0	0	+1	+3	+3	+3	+2	+1	0	0	-2	-3	-2	-3	-3	-3	-2	-1	0	I
I	-1	-1	0	+2	+3	+4	+4	+3	+2	0	-1	-1	-1	-1	-2	-3	-3	-2	-1	I
I	-2	-2	0	+1	+1	+3	+5	+4	+3	+1	0	0	0	0	-1	-2	-3	-3	-2	I
I	-3	-2	-1	0	+1	+2	+4	+4	+4	+4	+2	+1	+1	0	-1	-2	-3	-3	-3	I
I	-4	-3	-1	0	+1	+1	+3	+4	+6	+7	+5	+3	+2	0	0	0	-2	-4	-4	I
I	-4	-3	-1	0	0	+1	+2	+4	+7	+X	+7	+4	+2	+1	0	0	-1	-3	-4	I
I	-4	-4	-2	0	0	0	+2	+3	+5	+7	+6	+4	+3	+1	+1	0	-1	-3	-4	I
I	-3	-3	-3	-2	-1	0	+1	+1	+2	+4	+4	+4	+4	+2	+1	0	-1	-2	-3	I
I	-2	-3	-3	-2	-1	0	0	0	0	+1	+3	+4	+5	+3	+1	+1	0	-2	-2	I
I	-1	-2	-3	-3	-2	-1	-1	-1	-1	0	+2	+3	+4	+4	+3	+2	0	-1	-1	I
I	0	-1	-2	-3	-3	-3	-2	-3	-2	0	0	+1	+2	+3	+3	+3	+1	0	0	I
I	+1	0	-1	-3	-4	-4	-4	-4	-3	-2	-2	-1	0	+2	+3	+3	+3	+2	+2	I
I	+4	+2	0	-2	-4	-5	-5	-5	-5	-4	-4	-3	-1	0	+1	+4	+5	+5	+4	I
I	+5	+4	+1	-2	-4	-6	-6	-6	-6	-6	-5	-4	-3	-2	0	+3	+6	+6	+4	I
I	+4	+4	+1	-2	-4	-5	-5	-6	-6	-6	-6	-5	-4	-3	-1	+2	+5	+6	+6	I

UPPER 95. CONFIDENCE SURFACE, SOUTHEAST QUADRANT OF A SYMMETRICAL FUNCTION

0.1323	0.1359	0.1468	0.1596	0.1728	0.1895	0.2114	0.2416	0.2863	0.3601
0.1343	0.1420	0.1511	0.1620	0.1754	0.1923	0.2145	0.2452	0.2905	0.3655
0.1363	0.1441	0.1533	0.1644	0.1779	0.1951	0.2176	0.2487	0.2947	0.3707
0.1382	0.1461	0.1554	0.1666	0.1803	0.1977	0.2205	0.2520	0.2986	0.3756
0.1399	0.1479	0.1573	0.1686	0.1825	0.2000	0.2231	0.2548	0.3019	0.3798
0.1413	0.1493	0.1588	0.1701	0.1841	0.2018	0.2250	0.2570	0.3044	0.3829
0.1420	0.1500	0.1595	0.1709	0.1849	0.2026	0.2258	0.2579	0.3054	0.3842
0.1417	0.1496	0.1591	0.1704	0.1843	0.2018	0.2249	0.2567	0.3039	0.3821
0.1395	0.1473	0.1565	0.1675	0.1811	0.1983	0.2208	0.2519	0.2980	0.3744
0.1339	0.1413	0.1500	0.1605	0.1734	0.1896	0.2109	0.2403	0.2839	0.3562

LOWER 95. CONFIDENCE SURFACE, SOUTHEAST QUADRANT OF A SYMMETRICAL FUNCTION

-0.1029	-0.1091	-0.1164	-0.1252	-0.1361	-0.1499	-0.1679	-0.1930	-0.2301	-0.2915
-0.1049	-0.1112	-0.1187	-0.1277	-0.1388	-0.1528	-0.1713	-0.1968	-0.2347	-0.2975
-0.1070	-0.1134	-0.1210	-0.1302	-0.1415	-0.1558	-0.1747	-0.2008	-0.2395	-0.3037
-0.1090	-0.1156	-0.1233	-0.1327	-0.1443	-0.1589	-0.1782	-0.2048	-0.2444	-0.3101
-0.1110	-0.1177	-0.1256	-0.1352	-0.1470	-0.1619	-0.1816	-0.2088	-0.2493	-0.3164
-0.1129	-0.1197	-0.1278	-0.1375	-0.1496	-0.1648	-0.1848	-0.2126	-0.2539	-0.3225
-0.1145	-0.1214	-0.1297	-0.1396	-0.1518	-0.1673	-0.1877	-0.2160	-0.2580	-0.3280
-0.1156	-0.1226	-0.1309	-0.1410	-0.1533	-0.1690	-0.1897	-0.2184	-0.2610	-0.3321
-0.1156	-0.1227	-0.1310	-0.1411	-0.1535	-0.1693	-0.1901	-0.2189	-0.2618	-0.3334
-0.1137	-0.1206	-0.1289	-0.1388	-0.1510	-0.1666	-0.1871	-0.2156	-0.2581	-0.3290

SIGNIFICANT UPPER AUTOCORRELATION VALUES AT 95.PERCENT CONFIDENCE LEVEL, POSITIVE SHIFT

1.0000	0.7702	0.4584	0.2924	0.0	0.0	0.0	0.0	0.0	0.0
0.7600	0.6500	0.4521	0.3273	0.1886	0.0	0.0	0.0	0.0	0.0
0.4105	0.4587	0.4632	0.4241	0.2478	0.0	0.0	0.0	0.0	0.0
0.1984	0.3430	0.4709	0.5085	0.3486	0.1998	0.0	0.0	0.0	0.0
0.0	0.2039	0.3537	0.4602	0.4117	0.3227	0.2787	0.0	0.0	0.0
0.0	0.0	0.0	0.2840	0.3776	0.3637	0.3252	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.2470	0.3060	0.3710	0.3391	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.4309	0.5825	0.5152	0.4045
0.0	0.0	0.0	0.0	0.0	0.0	0.3660	0.6808	0.6465	0.4835
0.0	0.0	0.0	0.0	0.0	0.0	0.2116	0.5709	0.6739	0.6499

SIGNIFICANT LOWER AUTOCORRELATION VALUES AT 95.PERCENT CONFIDENCE LEVEL, POSITIVE SHIFT

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3743	-0.4850
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3419	-0.4454
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2894	-0.3702
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-0.2765	-0.2317	-0.1403	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-0.4982	-0.4235	-0.3059	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-0.6385	-0.5446	-0.4468	-0.3725	-0.2682	0.0	0.0	0.0	0.0	0.0
-0.6367	-0.6124	-0.5331	-0.4381	-0.3322	0.0	0.0	0.0	0.0	0.0

SIGNIFICANT UPPER AUTOCORRELATION VALUES AT 95.PERCENT CONFIDENCE LEVEL, NEGATIVE SHIFT

0.0	0.0	0.0	0.0	0.0	0.0	0.2924	0.4584	0.7702	1.0000
0.0	0.0	0.0	0.0	0.0	0.0	0.2242	0.3611	0.5663	0.7600
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4105
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1733	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.4102	0.2636	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5386	0.4121	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.4964	0.4337	0.1644	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SIGNIFICANT LOWER AUTOCORRELATION VALUES AT 95.PERCENT CONFIDENCE LEVEL,NEGATIVE SHIFT

-0.4850	-0.3743	-0.1627	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-0.4639	-0.4052	-0.2317	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-0.3440	-0.3738	-0.3186	-0.2139	0.0	0.0	0.0	0.0	0.0	0.0
-0.2034	-0.3070	-0.3459	-0.2934	-0.1653	0.0	0.0	0.0	0.0	0.0
-0.1436	-0.2613	-0.3288	-0.3400	-0.2583	-0.1663	0.0	0.0	0.0	0.0
0.0	-0.1632	-0.2575	-0.3562	-0.3461	-0.3117	-0.2863	-0.3055	0.0	0.0
0.0	0.0	0.0	-0.3021	-0.4105	-0.4419	-0.4112	-0.4078	-0.3857	0.0
0.0	0.0	0.0	-0.2290	-0.4568	-0.5535	-0.5491	-0.5570	-0.5723	-0.4982
0.0	0.0	0.0	-0.2325	-0.4890	-0.6057	-0.6272	-0.6588	-0.6913	-0.6385
0.0	0.0	0.0	-0.2443	-0.4952	-0.5985	-0.5967	-0.6201	-0.6559	-0.6367

MAP OF SIGNIFICANT POSITIVE AUTOCORRELATION COEFFICIENTS AT 95. PERCENT PROBABILITY LEVEL

COEFFICIENTS ARE MULTIPLIED BY 10
AN X INDICATES THE VALUE OF +1.0 OR -1.0 COEFFICIENTS

+6	+6	+5	+2	0	0	0	0	0	0	0	0	0	0	0	0	+1	+4	+4
+4	+6	+6	+3	0	0	0	0	0	0	0	0	0	0	0	0	0	+4	+5
+4	+5	+5	+4	0	0	0	0	0	0	0	0	0	0	0	0	0	+2	+4
0	0	+3	+3	+3	+2	0	0	0	0	0	0	0	0	0	0	0	0	+1
0	0	0	+3	+3	+3	+2	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	+2	+3	+4	+4	+3	+2	0	0	0	0	0	0	0	0	0	0
0	0	0	0	+1	+3	+5	+4	+3	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	+2	+4	+4	+4	+4	0	0	0	0	0	0	0	0	0
0	0	0	0	0	+1	+3	+4	+6	+7	+5	+3	+2	0	0	0	0	0	0
0	0	0	0	0	0	+2	+4	+7	+X	+7	+4	+2	0	0	0	0	0	0
0	0	0	0	0	0	+2	+3	+5	+7	+6	+4	+3	+1	0	0	0	0	0
0	0	0	0	0	0	0	0	0	+4	+4	+4	+4	+2	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	+3	+4	+5	+3	+1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	+2	+3	+4	+4	+3	+2	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	+2	+3	+3	+3	0	0	0
+1	0	0	0	0	0	0	0	0	0	0	0	0	+2	+3	+3	+3	0	0
+4	+2	0	0	0	0	0	0	0	0	0	0	0	0	0	+4	+5	+5	+4
+5	+4	0	0	0	0	0	0	0	0	0	0	0	0	0	+3	+6	+6	+4
+4	+4	+1	0	0	0	0	0	0	0	0	0	0	0	0	+2	+5	+6	+6

MAP OF SIGNIFICANT NEGATIVE AUTOCORRELATION COEFFICIENTS AT 95. PERCENT PROBABILITY LEVEL

COEFFICIENTS ARE MULTIPLIED BY 10
AN X INDICATES THE VALUE OF +1.0 OR -1.0 COEFFICIENTS

0	0	0	0	0	-3	-4	-5	-6	-6	-6	-6	-5	-5	-4	-2	0	0	0
0	0	0	0	0	-2	-3	-4	-5	-6	-6	-6	-6	-6	-4	-2	0	0	0
0	0	0	0	0	0	0	-3	-4	-4	-5	-5	-5	-5	-4	-2	0	0	0
0	0	0	0	0	0	0	-1	-2	0	-3	-4	-4	-4	-4	-3	0	0	0
0	0	0	0	0	0	0	0	0	0	0	-3	-2	-3	-3	-3	-2	-1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-2	-3	-3	-2	-1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-2	-3	-3	-2
-3	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	-3	-3	-3
-4	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	-4	-4
-4	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-3	-4
-4	-4	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-3	-4
-3	-3	-3	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	-3
-2	-3	-3	-2	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-1	-2	-3	-3	-2	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	-1	-2	-3	-3	-3	-2	-3	0	0	0	0	0	0	0	0	0	0	0
0	0	0	-3	-4	-4	-4	-4	-3	0	-2	-1	0	0	0	0	0	0	0
0	0	0	-2	-4	-5	-5	-5	-5	-4	-4	-3	0	0	0	0	0	0	0
0	0	0	-2	-4	-6	-6	-6	-6	-6	-5	-4	-3	-2	0	0	0	0	0
0	0	0	-2	-4	-5	-5	-6	-6	-6	-6	-5	-4	-3	0	0	0	0	0

UPPER 99. CONFIDENCE SURFACE, SOUTHEAST QUADRANT OF A SYMMETRICAL FUNCTION

0.1754	0.1855	0.1934	0.2118	0.2294	0.2517	0.2809	0.3212	0.3809	0.4795
0.1782	0.1885	0.2006	0.2151	0.2330	0.2556	0.2853	0.3262	0.3868	0.4870
0.1809	0.1913	0.2036	0.2184	0.2365	0.2594	0.2896	0.3311	0.3926	0.4943
0.1836	0.1941	0.2065	0.2215	0.2399	0.2631	0.2936	0.3357	0.3981	0.5013
0.1859	0.1966	0.2092	0.2243	0.2429	0.2664	0.2973	0.3399	0.4030	0.5075
0.1879	0.1986	0.2113	0.2265	0.2453	0.2690	0.3001	0.3431	0.4068	0.5123
0.1890	0.1998	0.2125	0.2278	0.2466	0.2704	0.3017	0.3448	0.4087	0.5147
0.1888	0.1995	0.2122	0.2274	0.2462	0.2698	0.3009	0.3438	0.4075	0.5131
0.1862	0.1966	0.2052	0.2241	0.2425	0.2657	0.2961	0.3382	0.4006	0.5042
0.1793	0.1893	0.2012	0.2154	0.2328	0.2549	0.2839	0.3239	0.3832	0.4818

LOWER 99. CONFIDENCE SURFACE, SOUTHEAST QUADRANT OF A SYMMETRICAL FUNCTION

-0.1173	-0.1243	-0.1326	-0.1426	-0.1549	-0.1706	-0.1911	-0.2195	-0.2616	-0.3312
-0.1195	-0.1267	-0.1352	-0.1454	-0.1579	-0.1739	-0.1948	-0.2238	-0.2668	-0.3380
-0.1218	-0.1291	-0.1378	-0.1482	-0.1610	-0.1773	-0.1986	-0.2282	-0.2721	-0.3449
-0.1241	-0.1315	-0.1404	-0.1510	-0.1641	-0.1807	-0.2025	-0.2327	-0.2776	-0.3519
-0.1263	-0.1339	-0.1429	-0.1537	-0.1671	-0.1840	-0.2063	-0.2371	-0.2829	-0.3589
-0.1284	-0.1361	-0.1453	-0.1563	-0.1699	-0.1872	-0.2099	-0.2413	-0.2880	-0.3655
-0.1302	-0.1380	-0.1473	-0.1585	-0.1723	-0.1898	-0.2129	-0.2449	-0.2924	-0.3714
-0.1313	-0.1392	-0.1486	-0.1595	-0.1739	-0.1916	-0.2150	-0.2473	-0.2955	-0.3756
-0.1312	-0.1392	-0.1486	-0.1599	-0.1739	-0.1917	-0.2151	-0.2476	-0.2960	-0.3766
-0.1288	-0.1366	-0.1459	-0.1571	-0.1708	-0.1883	-0.2114	-0.2434	-0.2911	-0.3708

SIGNIFICANT UPPER AUTOCORRELATION VALUES AT 99.PERCENT CONFIDENCE LEVEL, POSITIVE SHIFT

1.0000	0.7762	0.4584	0.2924	0.0	0.0	0.0	0.0	0.0	0.0
0.7600	0.6500	0.4521	0.3273	0.0	0.0	0.0	0.0	0.0	0.0
0.4105	0.4587	0.4632	0.4241	0.2478	0.0	0.0	0.0	0.0	0.0
0.1984	0.3430	0.4709	0.5085	0.3486	0.0	0.0	0.0	0.0	0.0
0.0	0.2039	0.3937	0.4602	0.4117	0.3227	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.2840	0.3776	0.3637	0.3252	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.2470	0.3060	0.3710	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.4309	0.5825	0.5152	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.3660	0.6808	0.6465	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5709	0.6739	0.6499

SIGNIFICANT LOWER AUTOCORRELATION VALUES AT 99.PERCENT CONFIDENCE LEVEL, POSITIVE SHIFT

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3743	-0.4850
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3419	-0.4454
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2894	-0.3702
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-0.2765	-0.2317	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-0.4582	-0.4235	-0.3059	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-0.6385	-0.5446	-0.4468	-0.3725	-0.2682	0.0	0.0	0.0	0.0	0.0
-0.0567	-0.6124	-0.5221	-0.4351	-0.3322	0.0	0.0	0.0	0.0	0.0

SIGNIFICANT UPPER AUTOCORRELATION VALUES AT 99.PERCENT CONFIDENCE LEVEL, NEGATIVE SHIFT

0.0	0.0	0.0	0.0	0.0	0.0	0.2924	0.4584	0.7702	1.0000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3611	0.5663	0.7600
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.4102	0.2636	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5386	0.4121	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.4964	0.4337	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SIGNIFICANT LOWER AUTOCORRELATION VALUES AT 99.PERCENT CONFIDENCE LEVEL,NEGATIVE SHIFT

-0.4850	-0.3743	-0.1627	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-0.4639	-0.4052	-0.2317	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-0.3440	-0.3738	-0.3186	-0.2139	0.0	0.0	0.0	0.0	0.0	0.0
-0.2034	-0.3070	-0.3459	-0.2934	-0.1653	0.0	0.0	0.0	0.0	0.0
-0.1436	-0.2613	-0.3288	-0.3400	-0.2583	0.0	0.0	0.0	0.0	0.0
0.0	-0.1632	-0.2575	-0.3562	-0.3461	-0.3117	-0.2863	-0.3055	0.0	0.0
0.0	0.0	0.0	-0.3021	-0.4105	-0.4419	-0.4112	-0.4078	-0.3857	0.0
0.0	0.0	0.0	-0.2290	-0.4568	-0.5535	-0.5481	-0.5570	-0.5723	-0.4982
0.0	0.0	0.0	-0.2325	-0.4890	-0.6057	-0.6272	-0.6588	-0.6913	-0.6385
0.0	0.0	0.0	-0.2443	-0.4952	-0.5985	-0.5967	-0.6201	-0.6559	-0.6367

MAP OF SIGNIFICANT POSITIVE AUTOCORRELATION COEFFICIENTS AT 99. PERCENT PROBABILITY LEVEL

COEFFICIENTS ARE MULTIPLIED BY 10
AN X INDICATES THE VALUE OF +1.0 OR -1.0 COEFFICIENTS

I	+6	+6	+5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+4	+4	I
I	0	+6	+6	+3	0	0	0	0	0	0	0	0	0	0	0	0	0	+4	+5	I
I	0	+5	+5	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	+2	+4	I
I	0	0	0	+3	+3	+2	0	0	0	0	0	0	0	0	0	0	0	0	0	I
I	0	0	0	+3	+3	+3	+2	0	0	0	0	0	0	0	0	0	0	0	0	I
I	0	0	0	0	+3	+4	+4	+3	+2	0	0	0	0	0	0	0	0	0	0	I
I	0	0	0	0	0	+3	+5	+4	+3	0	0	0	0	0	0	0	0	0	0	I
I	0	0	0	0	0	+2	+4	+4	+4	0	0	0	0	0	0	0	0	0	0	I
I	0	0	0	0	0	0	+3	+4	+6	+7	+5	+3	0	0	0	0	0	0	0	I
I	0	0	0	0	0	0	+2	+4	+7	+X	+7	+4	+2	0	0	0	0	0	0	I
I	0	0	0	0	0	0	0	+3	+5	+7	+6	+4	+3	0	0	0	0	0	0	I
I	0	0	0	0	0	0	0	0	0	0	+4	+4	+4	+2	0	0	0	0	0	I
I	0	0	0	0	0	0	0	0	0	0	+3	+4	+5	+3	0	0	0	0	0	I
I	0	0	0	0	0	0	0	0	0	0	+2	+3	+4	+4	+3	0	0	0	0	I
I	0	0	0	0	0	0	0	0	0	0	0	0	+2	+3	+3	+3	0	0	0	I
I	0	0	0	0	0	0	0	0	0	0	0	0	0	+2	+3	+3	0	0	0	I
I	+4	+2	0	0	0	0	0	0	0	0	0	0	0	0	0	+4	+5	+5	0	I
I	+5	+4	0	0	0	0	0	0	0	0	0	0	0	0	0	+3	+6	+6	0	I
I	+4	+4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+5	[illegible]	+6	I

MAP OF SIGNIFICANT NEGATIVE AUTOCORRELATION COEFFICIENTS AT 99. PERCENT PROBABILITY LEVEL

COEFFICIENTS ARE MULTIPLIED BY 10
AN X INDICATES THE VALUE OF +1.0 OR -1.0 COEFFICIENTS

I	0	0	0	0	0	-3	-4	-5	-6	-6	-6	-6	-5	-5	-4	-2	0	0	0	I
I	0	0	0	0	0	-2	-3	-4	-5	-6	-6	-6	-6	-6	-4	-2	0	0	0	I
I	0	0	0	0	0	0	0	-3	-4	-4	-5	-5	-5	-5	-4	-2	0	0	0	I
I	0	0	0	0	0	0	0	0	-2	0	-3	-4	-4	-4	-4	-3	0	0	0	I
I	0	0	0	0	0	0	0	0	0	0	0	-3	-2	-3	-3	-3	-2	-1	0	I
I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	-3	-3	-2	-1	I
I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-2	-3	-3	-2	I
I	-3	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	-3	-3	-3	I
I	-4	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	-4	-4	I
I	-4	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-3	-4	I
I	-4	-4	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-3	-4	I
I	-3	-3	-3	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	-3	I
I	-2	-3	-3	-2	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	I
I	-1	-2	-3	-3	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	I
I	0	-1	-2	-3	-3	-3	-2	-3	0	0	0	0	0	0	0	0	0	0	0	I
I	0	0	0	-3	-4	-4	-4	-4	-3	0	-2	0	0	0	0	0	0	0	0	I
I	0	0	0	-2	-4	-5	-5	-5	-5	-4	-4	-3	0	0	0	0	0	0	0	I
I	0	0	0	-2	-4	-6	-6	-6	-6	-6	-5	-4	-3	-2	0	0	0	0	0	I
I	0	0	0	-2	-4	-5	-5	-6	-6	-6	-6	-5	-4	-3	0	0	0	0	0	I

THIS PROBLEM IS FINISHED

DATA INPUT FORMAT IS (20X,F3.0)

FILTER INPUT FORMAT IS (3F4.0)

13 = NUMBER OF ROWS OF DATA
18 = NUMBER OF COLUMNS OF DATA
1 = NUMBER OF ROWS IN FILTER
1 = NUMBER OF COLUMNS IN FILTER
10 = NUMBER OF ROW LAGS, LR=1 MEANS ZERO LAGS
10 = NUMBER OF COLUMN LAGS, LC=1 MEANS ZERO LAGS
1 = NUMBER OF SAMPLE INTERVALS IN ONE ROW LAG
1 = NUMBER OF SAMPLE INTERVALS IN ONE COLUMN LAG

312.000	404.000	442.000	544.000	523.000	334.000	330.000	440.000	419.000	228.000	101.000	320.000
145.000	109.000	121.000	130.000	96.000	91.000						
321.000	510.000	514.000	453.000	470.000	354.000	296.000	319.000	355.000	222.000	106.000	114.000
154.000	142.000	139.000	110.000	94.000	89.000						
183.000	374.000	412.000	351.000	430.000	406.000	350.000	282.000	253.000	240.000	160.000	157.000
181.000	206.000	151.000	102.000	104.000	99.000						
182.000	246.000	285.000	347.000	482.000	448.000	401.000	315.000	246.000	275.000	301.000	268.000
238.000	185.000	119.000	140.000	114.000	109.000						
178.000	193.000	215.000	294.000	448.000	470.000	375.000	324.000	280.000	291.000	327.000	348.000
292.000	207.000	160.000	120.000	98.000	93.000						
162.000	258.000	295.000	346.000	417.000	405.000	350.000	364.000	363.000	292.000	241.000	266.000
285.000	296.000	261.000	163.000	104.000	99.000						
249.000	394.000	352.000	330.000	389.000	366.000	358.000	414.000	406.000	294.000	269.000	314.000
336.000	336.000	284.000	287.000	223.000	136.000						
285.000	383.000	336.000	125.000	214.000	346.000	364.000	378.000	433.000	425.000	433.000	426.000
333.000	336.000	342.000	362.000	322.000	279.000						
256.000	252.000	192.000	30.000	160.000	325.000	270.000	290.000	408.000	476.000	519.000	453.000
255.000	310.000	440.000	489.000	445.000	396.000						
283.000	236.000	150.000	77.000	149.000	262.000	224.000	262.000	358.000	407.000	437.000	423.000
291.000	293.000	426.000	521.000	468.000	385.000						
373.000	342.000	264.000	221.000	259.000	316.000	312.000	320.000	376.000	356.000	464.000	538.000
409.000	400.000	471.000	456.000	438.000	426.000						
338.000	384.000	390.000	371.000	382.000	435.000	412.000	337.000	313.000	276.000	439.000	648.000
561.000	474.000	468.000	395.000	404.000	501.000						
168.000	303.000	404.000	395.000	350.000	358.000	381.000	335.000	294.000	312.000	473.000	556.000
498.000	410.000	283.000	222.000	291.000	488.000						

AVERAGE OF ORIGINAL DATA = 311.226318
UNCORRECTED SUMS OF SQUARES = 3411039.000000
VARIANCE = 14639.652344
STANDARD DEVIATION = 120.594476

THE COEFFICIENTS OF THE REGRESSION PLANE OF THE DATA ARE COMPUTED AS

0.26086878D 03 0.11571917D 02 U -0.35206001D 01 V

LEVELLED DATA

42.680	138.201	179.721	285.242	267.762	82.283	81.803	195.324	177.845	-9.635	-133.114	-110.593
-82.073	-114.552	-99.032	-86.511	-116.990	-118.470						
39.708	232.229	235.749	182.270	202.790	130.311	35.832	62.352	101.873	-27.607	-140.086	-128.565
-85.045	-93.524	-93.004	-118.483	-130.962	-132.442						
-110.264	84.257	125.777	68.298	150.818	130.339	77.860	13.380	-12.099	-21.579	-98.058	-97.537
-70.017	-41.496	-92.976	-138.455	-132.934	-124.414						
-123.236	-55.715	-13.195	52.326	190.847	160.367	116.888	34.408	-31.071	1.450	30.970	1.491
-24.989	-74.468	-136.947	-112.427	-134.906	-136.386						
-139.208	-120.687	-95.167	-12.646	144.875	170.395	78.916	31.436	-9.043	5.478	44.998	69.519
17.039	-64.440	-107.919	-144.299	-162.878	-164.358						
-167.186	-67.655	-27.138	27.382	101.903	93.423	41.944	59.465	61.985	-5.494	-52.974	-24.453
2.068	12.588	-18.891	-113.371	-168.850	-170.329						
-92.152	56.369	17.890	-0.590	60.931	42.451	37.972	97.493	93.013	-15.466	-36.946	11.575
37.096	40.616	-7.863	-1.343	-61.822	-145.301						
-68.124	33.397	-10.082	-217.562	-125.041	10.479	32.000	49.521	108.041	103.562	115.082	111.603
22.124	28.644	38.165	61.685	25.206	-14.273						
-109.095	-109.575	-166.054	-324.533	-191.013	-22.492	-73.972	-50.451	71.069	142.590	189.111	126.631
-23.848	-9.328	124.193	176.714	136.234	90.755						
-94.067	-137.547	-220.026	-289.505	-213.985	-97.464	-131.944	-90.423	9.097	61.618	95.139	84.659
-43.820	-38.300	98.221	196.742	147.262	67.783						
-16.039	-43.519	-117.998	-157.477	-115.957	-55.436	-55.916	-44.395	15.126	-1.354	110.167	187.687
62.209	56.729	131.249	115.770	95.290	96.811						
-63.011	-13.491	-3.970	-19.449	-4.929	51.592	32.112	-39.367	-59.846	-93.326	73.195	285.715
202.236	118.757	116.277	46.798	59.318	159.839						
-244.983	-106.462	-1.942	-7.421	-48.901	-37.380	-10.859	-53.339	-90.818	-69.298	95.223	181.743
127.264	42.785	-80.095	-138.174	-65.653	134.867						

POSITIVE SHIFT AUTOCORRELATION MATRIX

1.0000	0.7702	0.4584	0.2924	0.1578	0.0835	0.0196	-0.1627	-0.3743	-0.4850
0.7600	0.6500	0.4521	0.3273	0.1886	0.1052	0.0411	-0.1477	-0.3419	-0.4454
0.4105	0.4587	0.4632	0.4241	0.2473	0.2083	0.0524	-0.1131	-0.2894	-0.3702
0.1984	0.3430	0.4709	0.5035	0.3466	0.1998	0.1612	-0.0071	-0.2108	-0.2844
0.0548	0.2039	0.3537	0.4602	0.4117	0.3227	0.2787	0.0764	-0.1630	-0.1735
-0.0727	0.0120	0.1145	0.2840	0.3776	0.3637	0.3252	0.1482	-0.0475	0.0047
-0.2765	-0.2317	-0.1403	0.0812	0.2470	0.3060	0.3710	0.3391	0.2391	0.2441
-0.4982	-0.4235	-0.3059	-0.1253	0.0267	0.1775	0.4309	0.5825	0.5152	0.4045
-0.6385	-0.5446	-0.4468	-0.3725	-0.2682	-0.0478	0.3660	0.6808	0.6465	0.4835
-0.5367	-0.6124	-0.5331	-0.4381	-0.3322	-0.1594	0.2116	0.5709	0.6739	0.6499

NEGATIVE SHIFT AUTOCORRELATION MATRIX

-0.4850	-0.3743	-0.1627	0.0196	0.0835	0.1578	0.2924	0.4584	0.7702	1.0000
-0.4639	-0.4052	-0.2317	-0.0777	-0.0207	0.0651	0.2242	0.3611	0.5663	0.7600
-0.3440	-0.3738	-0.3186	-0.2139	-0.1148	-0.0029	0.1108	0.1585	0.2385	0.4105
-0.2034	-0.3070	-0.3459	-0.2934	-0.1653	-0.0360	0.0300	-0.0342	-0.0103	0.1984
-0.1436	-0.2613	-0.3288	-0.3400	-0.2583	-0.1663	-0.1305	-0.1979	-0.1607	0.0548
-0.0444	-0.1632	-0.2575	-0.3562	-0.3461	-0.3117	-0.2863	-0.3055	-0.2443	-0.0727
0.1733	0.0422	-0.1072	-0.3021	-0.4105	-0.4419	-0.4112	-0.4078	-0.3857	-0.2765
0.4102	0.2636	0.0636	-0.2290	-0.4568	-0.5535	-0.5481	-0.5570	-0.5723	-0.4982
0.5386	0.4121	0.1378	-0.2325	-0.4890	-0.6057	-0.6272	-0.6588	-0.6913	-0.6385
0.4964	0.4337	0.1644	-0.2443	-0.4952	-0.5985	-0.5967	-0.6201	-0.6559	-0.6367

MAP OF AUTOCORRELATION MATRIX

COEFFICIENTS ARE MULTIPLIED BY 10
AN X INDICATES THE VALUE OF +1.0 OR -1.0 COEFFICIENTS

I	+5	+6	+5	+2	-1	-3	-4	-5	-6	-6	-6	-6	-5	-5	-4	-2	+1	+4	+4	I
I	+4	+6	+6	+3	0	-2	-3	-4	-5	-6	-6	-6	-6	-6	-4	-2	+1	+4	+5	I
I	+4	+5	+5	+4	+1	0	-1	-3	-4	-4	-5	-5	-5	-5	-4	-2	0	+2	+4	I
I	+2	+2	+3	+3	+3	+2	0	-1	-2	-2	-3	-4	-4	-4	-4	-3	-1	0	+1	I
I	0	0	+1	+3	+3	+3	+2	+1	0	0	-2	-3	-2	-3	-3	-3	-2	-1	0	I
I	-1	-1	0	+2	+3	+4	+4	+3	+2	0	-1	-1	-1	-1	-2	-3	-3	-2	-1	I
I	-2	-2	0	+1	+1	+3	+5	+4	+3	+1	0	0	0	0	-1	-2	-3	-3	-2	I
I	-3	-2	-1	0	+1	+2	+4	+4	+4	+4	+2	+1	+1	0	-1	-2	-3	-3	-3	I
I	-4	-3	-1	0	+1	+1	+3	+4	+6	+7	+5	+3	+2	0	0	0	-2	-4	-4	I
I	-4	-3	-1	0	0	+1	+2	+4	+7	+X	+7	+4	+2	+1	0	0	-1	-3	-4	I
I	-4	-4	-2	0	0	0	+2	+3	+5	+7	+6	+4	+3	+1	+1	0	-1	-3	-4	I
I	-3	-3	-3	-2	-1	0	+1	+1	+2	+4	+4	+4	+4	+2	+1	0	-1	-2	-3	I
I	-2	-3	-3	-2	-1	0	0	0	0	+1	+3	+4	+3	+3	+1	+1	0	-2	-2	I
I	-1	-2	-3	-3	-2	-1	-1	-1	-1	0	+2	+3	+4	+4	+3	+2	0	-1	-1	I
I	0	-1	-2	-3	-3	-3	-2	-3	-2	0	0	+1	+2	+3	+3	+3	+1	0	0	I
I	+1	0	-1	-3	-4	-4	-4	-4	-3	-2	-2	-1	0	+2	+3	+3	+3	+2	+2	I
I	+4	+2	0	-2	-4	-5	-5	-5	-5	-4	-4	-3	-1	0	+1	+4	+5	+5	+4	I
I	+5	+4	+1	-2	-4	-6	-6	-6	-6	-6	-5	-4	-3	-2	0	+3	+6	+6	+4	I
I	+4	+4	+1	-2	-4	-5	-5	-6	-6	-6	-6	-5	-4	-3	-1	+2	+5	+6	+6	I

THIS PROBLEM IS FINISHED

DISTRIBUTION LIST

	Copies
NASA Headquarters, Washington, D. C.	
Dr. John R. Porter, for SAR Program Chief	1
James F. Seitz	3
Col. A. P. Colvorocesses, Chairman, Photography Instrument Team	1
Miss Winnie Morgan, Technical Reports Officer	5
NASA/MSC-Houston	
Leo F. Childs, Chairman, Aircraft Coordination	1
Ed Zeitler, Data Center	20
Charles M. Grant, Jr.	1
Bill Hand	1
Norman G. Foster, Manager, Earth Resources Aircraft Program	1
Olav Smistad, Org. TF3	1
USGS, Washington, D. C.	
William A. Fischer, Research Coordinator	1
W. D. Carter, Geology Coordinator	1
A. C. Gerlach, Geography Coordinator	1
W. Sibert, Cartography Coordinator	1
C. V. Robinove, Hydrology Coordinator	1
R. W. Fary, Chief, RESECS	1
W. R. Hemphill, Chairman, UV Instrument Team	1
J. D. Friedman	1
R. H. Alexander	1
USDA, Washington, D. C.	
A. B. Park, Agriculture/Forestry Coordinator	1
NRL, Washington, D. C.	
A. G. Alexiou, Oceanography Coordinator	1
Others	
R. N. Colwell, University of California, Berkeley	1
R. J. P. Lyon, Standford University	2
R. K. Moore, University of Kansas, Chrm. Radar Instr. Team	1
D. B. Simonett, University of Kansas	1
D. B. Slemmons, University of Nevada	1
J. Quade, University of Nevada	1
J. Lintz, University of Nevada	1
F. Barath, JPL, Chairman, Microwave Instrument Team	1
J. E. Conel, JPL	1
J. F. Cronin, AFCRL	1
W. Vest, IIT Research Institute, Washington, D. C.	1

NASA Grant NGR-14-007-027

N.U. Report #	Title	MSC Data Bank #	STAR #
1	Interim progress report 3-31-65	NR-09-00-000-00009	
2	Semi-annual status report 9-30-65		
3	Semi-annual status report 3-31-66	NR-06-00-000-00020	
4	Aspects of geological sampling at test sites	NR-09-00-000-00011	
5	Preliminary details of sampling locations at NASA Sonora Pass Test Site, California	NR-08-DK-019-00010	
6	Semi-annual status report 9-30-66	NR-06-00-000-00030	
7	Statistical problems involved in remote-sensing of the geology of the lithosphere-atmosphere interface	NR-09-00-000-00035	
8	The general linear equation in prediction of gold content in Witwatersrand rocks, South Africa	NR-09-00-000-00036	
9	Semi-annual status report 3-31-67	NR-06-00-000-00031	
10	FORTRAN IV programs to determine surface roughness in topography for the CDC 3400 computer	NR-09-00-000-00284	
11	A program for the rapid screening of multivariate data from the earth sciences and remote-sensing	NR-09-00-000-00052	

2

N.U. Report #	Title	MSC Data Bank #	STAR #
12	Two programs for the factor analysis of geologic and remote-sensing data	NR-09-DL-019-00067	
13	The geology of the lower Precambrian rocks of the Champion-Republic area of Upper Michigan (NASA Test Site 126)	NR-09-CN-126-00068	
14	The geochemistry of the Fremont Lake quartz monzonites and associated gruss, NASA Sonora Pass Geologic Test Site, Sierra Nevada, California	NR-09-DL-019-00073 (NASA-CR-90048)	N68-10180*CSCL 08D
15	Semi-annual status report		
16	Variance of some selected attributes in granitic rocks	NR-09-DK-998-00181 (NASA-CR-101747)	N69-30686*#CFSTICSCL08G
17	FORTRAN IV CDC 6400 program to analyze subsurface fold geometry	NR-08-OC-000-00080	
18	Semi-annual status report 9-30-68		
19	NASA Geological Test Site #126 Marquette-Republic Troughs, Michigan: Report on photographic imagery obtained on Mission 72, May, 1968	(NASA-CR-97790)	N69-12097*#CFSTICSCL08G
20	Relict diagenetic textures and structures in regional metamorphic rocks, Northern Michigan (NASA Geological Test Site # 126)		
21	A FORTRAN IV program for two-dimensional autocorrelation analysis of geologic and remotely-sensed data		