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CLIMATIC NORMALS AS PREDICTORS

Part 4: Verification

by

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Aerospace Instrumentation Laboratory

prepared for

AIR FORCE CAMBRIDGE RESEARCH LABORATORIES
OFFICE OF AEROSPACE RESEARCH
UNITED STATES AIR FORCE
BEDFORD, MASSACHUSETTS
01730

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C L I M A T I C N O R M A L S A S P R E D I C T O R S

Part 4: VERIFICATION

BY

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ABSTRACT

The length of the antecedent period for which the mean provides the minimum variance estimate of the next year's temperature, rainfall, and number of rainy days is calculated for a U.S. climatological benchmark station, a variety of foreign stations, and for percent of possible sunshine at 9 U.S. stations. Results verify the findings reported previously, and found by other authors, that the optimum record length varies widely from element to element and month to month, but shows some regional consistency. For all elements, stations, and months combined, all antecedent periods 10 to 40 years long yield averages which, on the whole, are about equal in predictive accuracy.

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CLIMATIC NORMALS AS PREDICTORS, 4 : VERIFICATION

1. General

Mean values of a climatic element during some antecedent period often are used to estimate the value of that element to be expected in the next month or year. In many cases, the antecedent period is the 30-year interval for which the mean is designated as a "normal." In other cases, the antecedent period is some k years immediately preceding the month or year for which prediction is desired. In five preceding studies, summarized in Scientific Report No. 1 ("SR 1" henceforth), the number of years for which the average yielded the minimum variance estimator for the next year's value was found to be generally less than 30, for monthly and annual temperature and precipitation, and annual streamflow.

These findings were extended, in SR 2, to monthly and annual temperature and precipitation at seven United States stations which had passed routine tests of "homogeneity" so that their data were published in World Weather Records. Despite their acceptance for use in studying long-range forecasting, climatic change, and similar problems these records were found, by the analysis in SR 2, to contain apparent changes in mean and in variance. To investigate the prevalence of such changes, the same analysis has been applied to the temperature and precipitation data of a U.S. "benchmark" climatological station and of several long-record foreign stations, and to the percent of possible sunshine, month by month, at each of nine U. S. stations.

For each element in each month, the interest is chiefly in defining the number of years, k^* ("k-star") over which a moving average, for the record used, provides the minimum variance estimator of the $k + 1$st value, i.e. the value of k minimizing the extrapolation variance

$$S^2_{k\ell m} = \frac{1}{n-k-\ell-m+2} \sum_{i=1}^{n-k-\ell-m+2} \left[\frac{1}{\ell} \sum_{j=m}^{m+\ell-1} x_{i+j+k-1} - \frac{1}{k} \sum_{j=0}^{k-1} x_{i+j} \right]^2$$

As in previous Reports, the results are presented chiefly as graphs of S_k^2 for $k = 1,2,3,\ldots,50$, on paper with lines giving $S_k^2 = s^2\,(1 + 1/k)$ for arbitrary values of s^2. As explained in SR 1 and mentioned in SR 2 and SR 3, this represents the manner in which S_k^2 should decrease if the observations are independent normal variates with the same mean and variance. For random samples of 100 numbers, S_k^2 varied noticeably from this theoretical line, on the scale used here, but for a sample of 1,000 it followed the line very closely. To study how sample size influences the behavior of S_k^2, records extending over two centuries or more are studied here.

2. Woodstock, Md.

At Woodstock, Md., about 16 miles WNW of Baltimore, climatological records have been maintained virtually without interruption since 1870, according to Landsberg, Mitchell, and Crutcher (1959). "The length and quality of these records, evident stability of station location in the more recent years, apparent freedom from environmental influence and change, and good prospects of future record continuity, have qualified Woodstock as a member of the Weather Bureau's Climatological Benchmark Network."

Rigorous analysis of the homogenity of these records since 1893 by these authors "revealed two discontinuities in temperature which were evidently associated with undocumented station moves about March 1901 and about January 1914. Between 1901 and 1914, mean temperatures were registering about 2.5 deg F too high in winter and about 1.5 deg too high in summer, relative to the record since 1914. The record prior to 1901 was approximately homogeneous with the record since 1914.

"This analysis also indicates that the precipitation record is homogeneous, with the possible exception of a period of several years between 1930 and 1940, when the gage catch at Woodstock was apparently deficient by about 6 percent...."

From punched cards for Woodstock, which had previously been supplied by Dr. Landsberg, then Director of the Office of Climatology, U.S.W.B., for student research, means of maximum and minimum temperature and totals of precipitation and days with measureable rain were compiled for each month in the 66 years, 1897-1962. From the maximum and minimum temperatures, midrange temperatures were computed, in accordance with standard U.S. practice; the "average" temperatures at 7 U.S. stations, examined in SR 2, are actually midranges. For each of the five series, S_k^2 was computed for each month of the year; results are shown in Figs. 1 through 5.

Any inhomogeneity in instrumental exposure or in observational practice, if it affects maximum and minimum temperatures similarly, might be expected to cause the S_k^2 curves for the two readings to be similar. At Woodstock, the January curves (Figs. 2A, 3A) are remarkably alike, the February and October curves somewhat alike, but the March and December curves are markedly dissimilar. The other months show no obvious correspondences nor disagreements.

The curve for the midrange (Fig. 1) resembles its two components in January and to a lesser extent in February. The March curve is a compromise between dissimilar components.

In September and October, the curves for maximum and minimum are quite erratic, suggesting changes in variance, but the curves for the midranges are much smoother, departing much less from the theoretical 1 + 1/k line. In December, the curve for maximum temperature wanders much less than that for the minimum, whose behavior suggests a change in mean, as does that for the midrange.

Values of k* (Fig. 12A) vary from 2 years (for maximum in July) to 50 years (for maximum in January and minimum in July), but most of them tend to be around 30 to 50 years. However, in a 66-year record, only the last 16 years are available to define S_k^2 for k = 50, and only the last 26 for k = 40.

Precipitation amount and number of rainy days measure two different aspects of precipitation, yet might be expected to show some similarities in behavior. Certainly the same length of records would be desirable for defining a "normal" for either. Yet the rainy day S_k^2 curves are much more erratic than the amount curves (Fig. 4), especially in the first half of the year. The rainy day curves are similar to those for random numbers with a change in mean (SR 1, Figs. 8, 10, 12) in February, March, June, July, November, and December, and with a change in variance (SR 1, Figs. 9, 11, 13) in January, April, and also July; the curves for precipitation are reasonably smooth except in July, August, and September, which seem to reflect changes in both mean and variance.

Values of k* (Fig. 12A) vary from 6 years (for amount in May) to 49 (for amount in July and rainy days in September). No consistency can be seen in the k* data for Woodstock; just as was found for temperature and precipitation at seven other U.S. station (SR 2), the mean for almost any antecedent period from 10 years onward apparently would provide a suitable estimate of the next year's value.

That the S_k^2 curves for each element behave differently in different months, and differently in the same month for various elements, indicates that their erratic behavior is not the consequence of the station inhomogeneities found by Landsberg et al. Rather the various elements have different histories, month by month. The erratic behavior of S_k^2 reflects the basic erraticness of climate itself, not of its measurement.

3. Precipitation

To determine whether the behavior of S_k^2 at seven U. S. stations (SR 2) and Woodstock, just discussed, differed in other regions with different climates and different observational practices, rainfall records from Europe, Africa, and Asia were analyzed in the same way. These included a 118-year record for Seoul, Korea (1776-1893) offered by Sekiguti (1965), a 120-year record for Capetown (Hofmeyr and Schulze, 1963), and a 96-year record for Valletta, Malta (Mitchell, 1963). Also used are records of 97 and 135 years for Basel and Geneva, Switzerland, and of 100 years for Jerusalem, Israel, taken from World Weather Records, 1951-1960, vol. 2.

The Seoul rainfall record was reconstructed from handwritten field notes discovered at the end of the last century. Although the tabulations begin in 1770 for amount and 1626 for rainy days, unavoidable gaps restrict the period without omissions to 1776-1893 for amount and 1773-1893 for days. The latter is the only long tabulation of rainy days readily available for comparison with the Woodstock series. The S_k^2 curves for Seoul are much smoother than those for Woodstock, which are based on a record scarcely half as long.

In contrast to the different behavior at Woodstock, the Seoul curves for rainy days and precipitation amount are generally similar in each month, but differ in detail. The annual curves (Figs. 6A and 11B) show a k* at 17 years, and an upward trend suggestive of change in mean. The curves for the wet months of July, August, and September all behave similarly, in general. The other curves follow, somewhat roughly, the theoretical lines. But k* is far from consistent between the two variables, and from month to month (Fig. 12B).

Basel and Geneva are about 180 km (115 miles) apart, with similar but not identical climates. World Weather Records offer no hints of inhomogeneities due to changes in exposure or observational practice. Yet the S_k^2 curves (Figs. 8, 9) for monthly precipitation suggest changes in mean or variance, but not necessarily in the same month at both places.

Abrupt decreases in extrapolation variance occur at Basel in June (at $k = 9$) and September (at $k = 18$), and at Geneva in May (at $k = 30$) and December (at $k = 15$). In general, the corresponding curves at these two places are much less similar than were corresponding curves at Memphis, Tenn., and Cairo, Ills., (SR 2), which are slightly farther apart. This lack of similarity may arise from the different lengths of record used, 95 years at Basel and 135 years at Geneva; the Memphis and Cairo records covered identical periods.

The "proposed standard series" of monthly rainfall data for Malta was reconstructed by Mitchell (1963) from observations at five locations in and near the city beginning in 1841, and is without gaps from 1865 to 1960. The data "for Jerusalem (Old City) replace that published in the earlier issues" of World Weather Records. Until 1914 the rainfall observations, in the Old City, were "corrected for faulty interpretations of measurements and for measurements with faulty instruments by comparison with synchronous measurements at other stations or with other instruments at the same station." For subsequent years, data from 14 stations within the urban area of Jerusalem, at distances up to 4 km with elevation differences up to 60 meters, were used "to reconstruct the continuation of the series..."

The monthly precipitation records for these two dry-summer stations, despite the care with which they were constructed, appear to have changes in mean and variance, as shown by the s_k^2 curves (Figs. 10, 11A), especially in October at Valletta. The curves seem just as irregular as those for the 7 U.S. stations (SR 2) and for Woodstock. Ignoring the dry months from May through August at Valletta (shown at the bottom of Figs. 10A and 10B) and May through October at Jerusalem (not even computed), k^* varies at Valletta from 12 and 15 years (October and March) to 50 years (December) and at Jerusalem from 15 years (March) to 49 years (April).

Curves of s_k^2 for annual (January-December) precipitation are shown on Fig. 11B for Seoul, Basel, Geneva, Valletta, and Jerusalem. Also shown is a curve for the "rainfall year" (July-June) precipitation at Jerusalem, and for annual precipitation at Capetown, South Africa. Hofmeyr and Schulze (1963) computed means and linear trends of the Capetown precipitation, for successive 30-year periods, as:

Period	1841-70	1871-1900	1901-1930	1931-1960
Mean (mm)	616.6	683.4	600.4	619.8
Trend (mm/yr)	+ 2.0	- 2.4	- 8.1	+ 3.3

The return of the mean to approximately its initial value may explain why the s_k^2 curve shows relatively little fluctuation.

The two Jerusalem curves, using the same data grouped into calendar and rainfall year, respectively, show interesting and significant differences: for the rainfall year k^* = 17 years, for the calendar year k^* = 10 or 31 years! Other values of k^* are 16 at Geneva, 18 at Seoul, 30 at Basel, 34 at Valletta, and 43 at Capetown. The optimum length of record for a precipitation "normal" which will provide the closest estimate of next year's rainfall is indeed elusive.

4. Temperature

Monthly temperature records covering two centuries at two places and almost as long at a third were readily available, in World Weather Records 1951-1960, vol. 2, for examination of the effect of length of record on the behavior of the extrapolation variance. Besides Basel (1755-1960) and Geneva (1768-1960), for which shorter precipitation records have already been discussed, data (1781-1960) were used for Hohenpeissenberg, Germany, a temperature record which has been examined in other connections by Keil (1961, 1967) and Burdecki (1962). Hohenpeissenberg, some 50 km (30 miles) SW of Munich, is about 250 km (160 miles) ENE of Basel, but at 913 meters is much higher than either Basel (317 meters) or Geneva (405 meters).

The 19th century was colder at Basel and Hohenpeissenberg than either the late 18th or the first half of the 20th. The inter-annual variability, closely related to the extrapolation variance, declined sharply at the end of the 19th century, and has since increased.

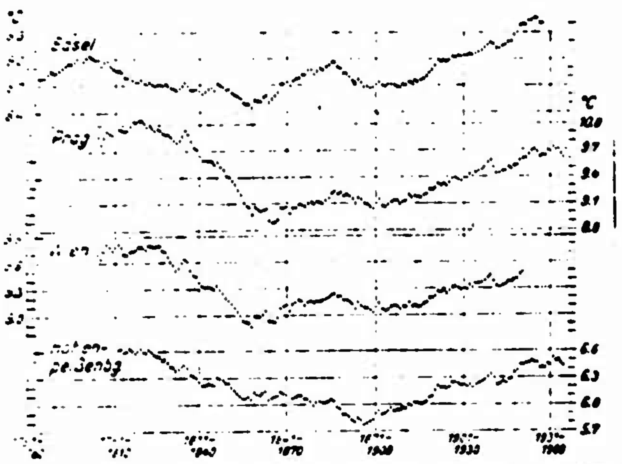

Abb. 3. Dreißigjährige übergreifende Mittelwerte der Temperatur von Basel, Prag, Wien und Hohenpeißenberg (Jahresmittel °C)

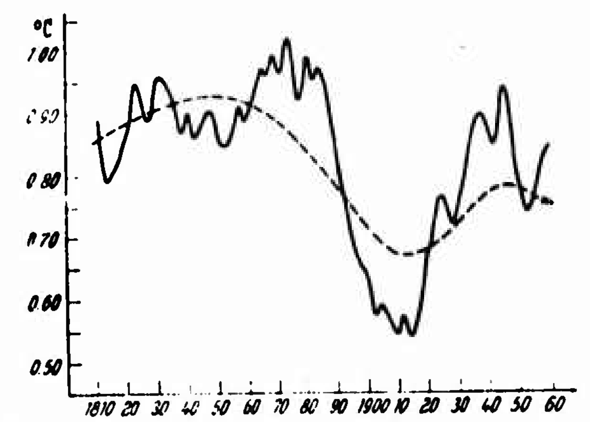

Abb. 1. 30jährige Mittel der Jahr-zu-Jahr-Änderungen der Jahresmittel der Lufttemperatur auf dem Hohenpeißenberg

The left-hand diagram of 30-year moving averages of annual temperature at four places is taken from Keil (1967), the right-hand diagram of corresponding 30-year moving averages of year-to-year change in annual temperature from Burdecki (1962).

These trends are not reflected in the graphs of s_k^2 for annual temperatures (Fig. 19A) at the three stations. Curves for Basel and Geneva are generally similar in rising farther and farther above the theoretical line, but with much more variation than if the mean had been constant during the period.

Monthly temperature curves at all three stations (Figs. 13, 14, 15) are smoother than those for shorter records. Despite the general proximity of the three stations, their curves show little correspondence, month by month. An abrupt drop in extrapolation variance occurs at Basel in December, at k = 33, but not at either of the others; the similar sharp drop at Geneva in March, at k = 17, is not reflected elsewhere.

Values of k* are generally more than 40 years at these three stations, although it is 16 or 17 years in June, August, and September at Basel and in September at Hohenpeissenberg. But the curves are generally so flat that a mean temperature for any period of 15 years or longer is adequate for estimating the mean monthly temperature of the next year.

To examine further the effect of record length, each of the monthly records was cut in half, and s_k^2 computed for each portion. Results, in Figs. 16, 17, and 18 are surprising and somewhat disconcerting. Not only is there no correspondence in the curves from month to month at one station for one period, or between stations for the same month for one period, but at each of the three stations the curves for the same month differ from the early period to the later one.

The behavior of the extrapolation variance does not depend on the method or place of observation, but only on the characteristics of the weather during the period for which it is computed. These characteristics change sufficiently from period to period that no extrapolation seems warranted.

This conclusion is equally appropriate to the annual curves for the two periods (Fig. 19B). The only consistent relation is that the actual extrapolation variance, in squared degrees, is higher for the first half of the record than for the second half, at all three stations. But the variations, as k increases, are markedly different between periods at any one station, and between stations in either period. The annual curves for the half-periods are much more erratic than those for the full period (Fig. 19A).

5. Sunshine

As a final verification of the findings concerning extrapolation variance, it was computed for an entirely different climatic variable. The percent of possible sunshine received day by day, for 57 years (1905-1962) at each of eight stations, and for 68 years at a ninth (Boston, 1894-1962), had been compiled for a study by Lund (1965) of the possible effect on cloudiness, as measured by sunshine, of lunar phase.

The automatically-recorded "number of minutes the sun shone each day is divided by the number of minutes from sunrise to sunset, to remove variations due solely to the time of year," to yield "per cent of possible sunshine." From these daily figures, monthly averages, as computed and supplied on tape by Mr. Lund, were analyzed for extrapolation variance. Perhaps because "these records are subject to considerable error," perhaps because this climatic element may be inherently more variable than temperature, precipitation or number of rainy days, or perhaps merely because the records are shorter than these for other elements studied, the results are so erratic as to defy analysis.

The s_k^2 curves (Figs. 21-29) fluctuate widely, rising sharply in some months and falling just as sharply in adjacent months. The stations are too far apart (the closest pair, Columbia and Oklahoma City, are separated by about 600 km or 375 miles) for any inter-station similarity. Even when the curves for $k > 30$ are ignored, because they are based on only 25 or fewer observations, the patterns show no consistency.

The mean percentage of possible sunshine over a period of 10 years, or even less, is as good an estimator of the next year's percentage as a mean for any long period.

5. Conclusions

Extrapolation variances have been computed for temperature, precipitation, rainy days, and sunshine for a variety of places around the world. Frequency distributions of these variables differ widely. Those of temperature are approximately normal, those of precipitation and rainy days tend to be skewed positively, while those of sunshine (Lund, 1965, Fig. 12) are U-shaped, with 0% and 100% much more frequent than other percentages. But for these various elements, the extrapolation variances behave similarly.

The over-all length of the climatic record from which s_k^2 is computed appears to control, generally, the smoothness of the resulting graph, but not necessarily how well it follows the theoretical line of $1 + 1/k$, appropriate to a random sample from a single population (same mean and variance) without correlation.

The erratic behavior of extrapolation variance, with increasing length of period used to define the predictor, appears to be related to the innate variability with time of a climatic element, rather than to methods of observation. This innate variability is not consistent from month to month, and not always the same for closely related quantities, such as maximum and minimum temperature, or precipitation amount and frequency (rainy days). For each of these variables, little if any gain in precision is attained by using a 30-year mean as an estimate of the next year's value; predictions which are not much worse, and in many cases better, are provided by means from only 10 or 15 years -- or 40 or 50 years.

For all the variables studied here, absolute prediction errors were also computed, for prediction using the median as well as the mean. In general, prediction based on the <u>median</u> had slightly less error than that using the mean, in verification of the findings in SR 2 for temperature and precipitation at 7 U.S. stations. Because the Q_k and D_k curves were generally similar to the S_k^2 curves, they were not completed and are not included here.

Still to be examined, in the next Report, is the behavior of extrapolation variance for prediction more than one year ahead.

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Variation of S_k^2 with k at 16 stations for temperature (TEMP), precipitation (PREC), number of rainy days (RAINDAY), and percent of possible sunshine (SUN) is shown in the following figures:

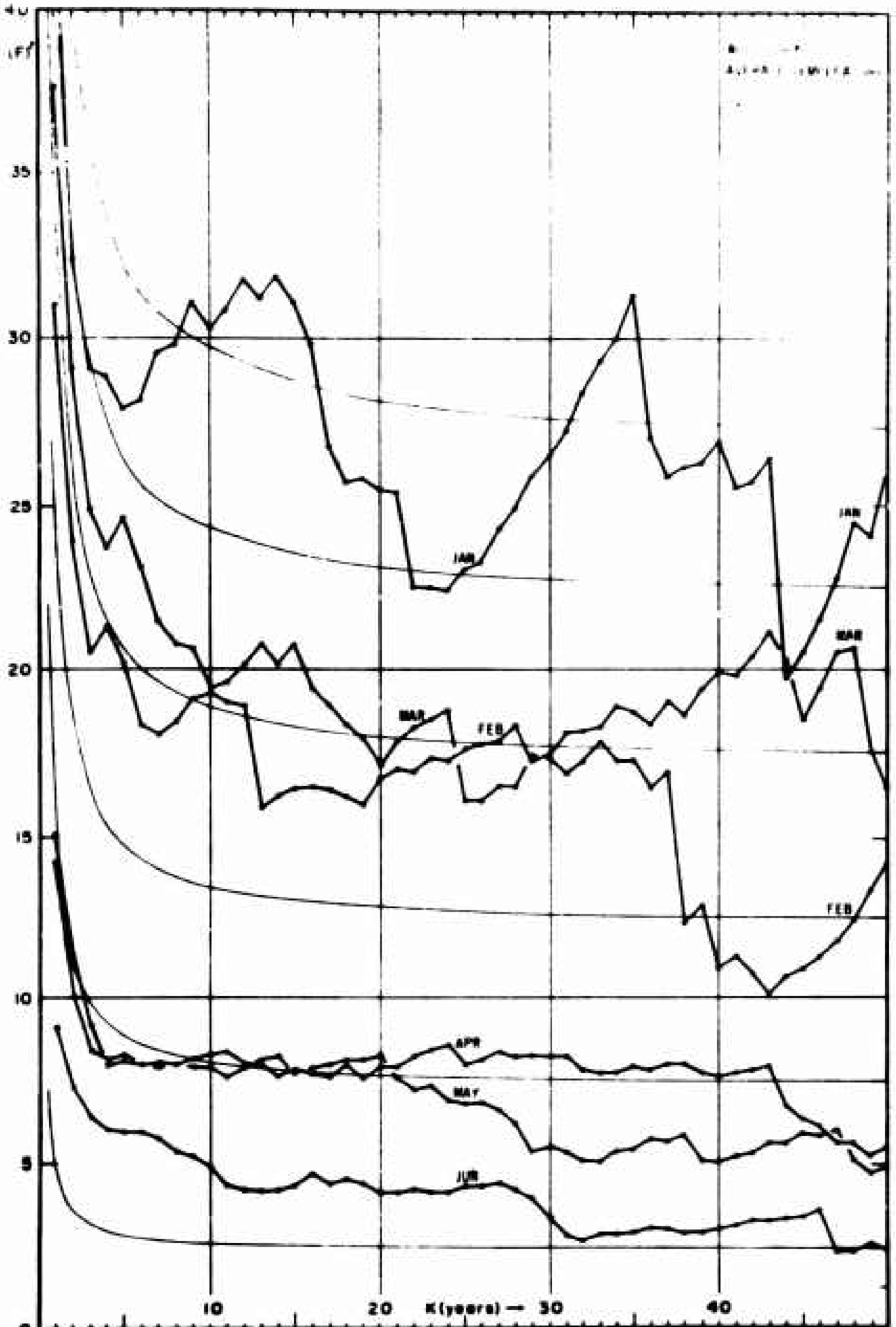


FIGURE 1A

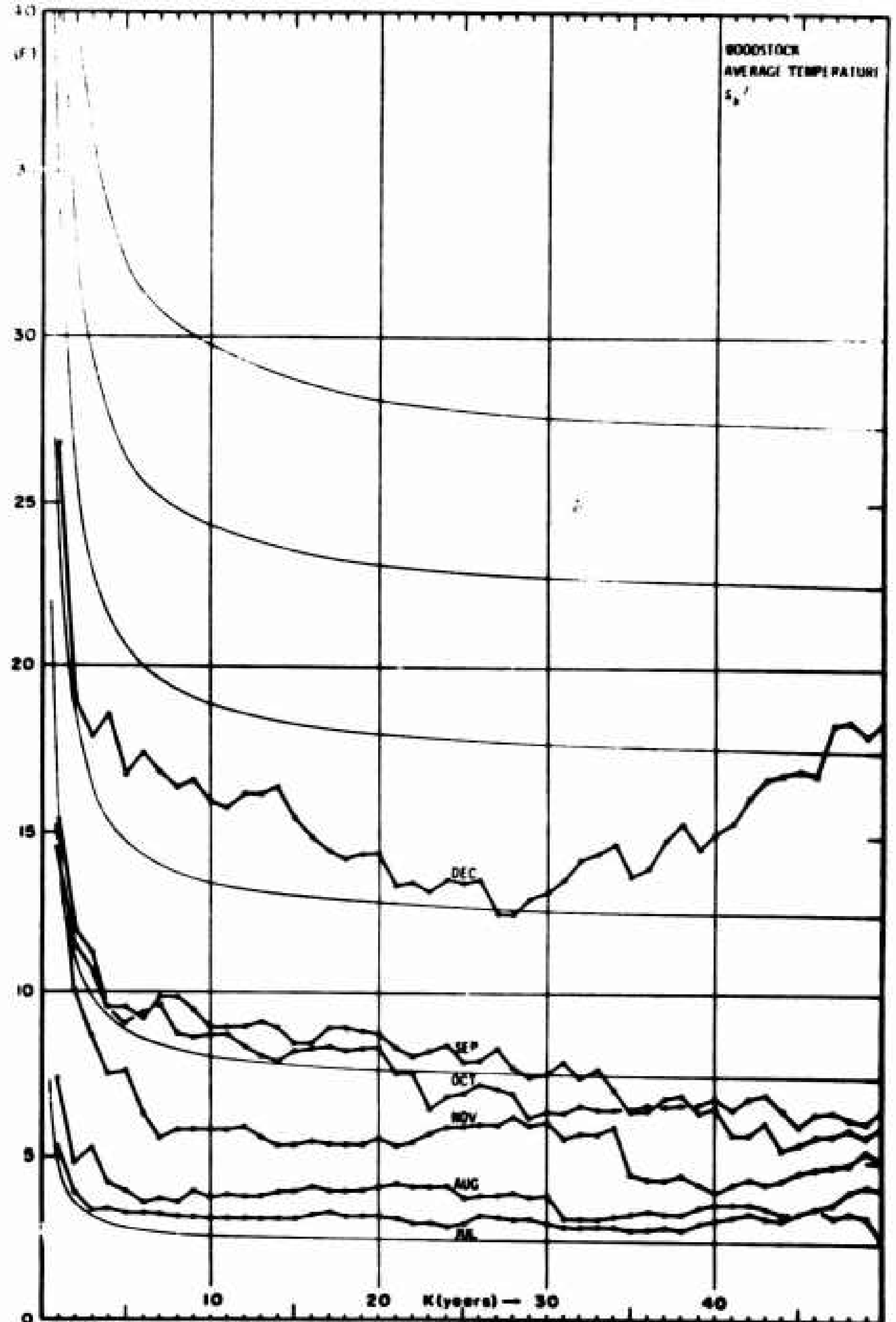


FIGURE 1B

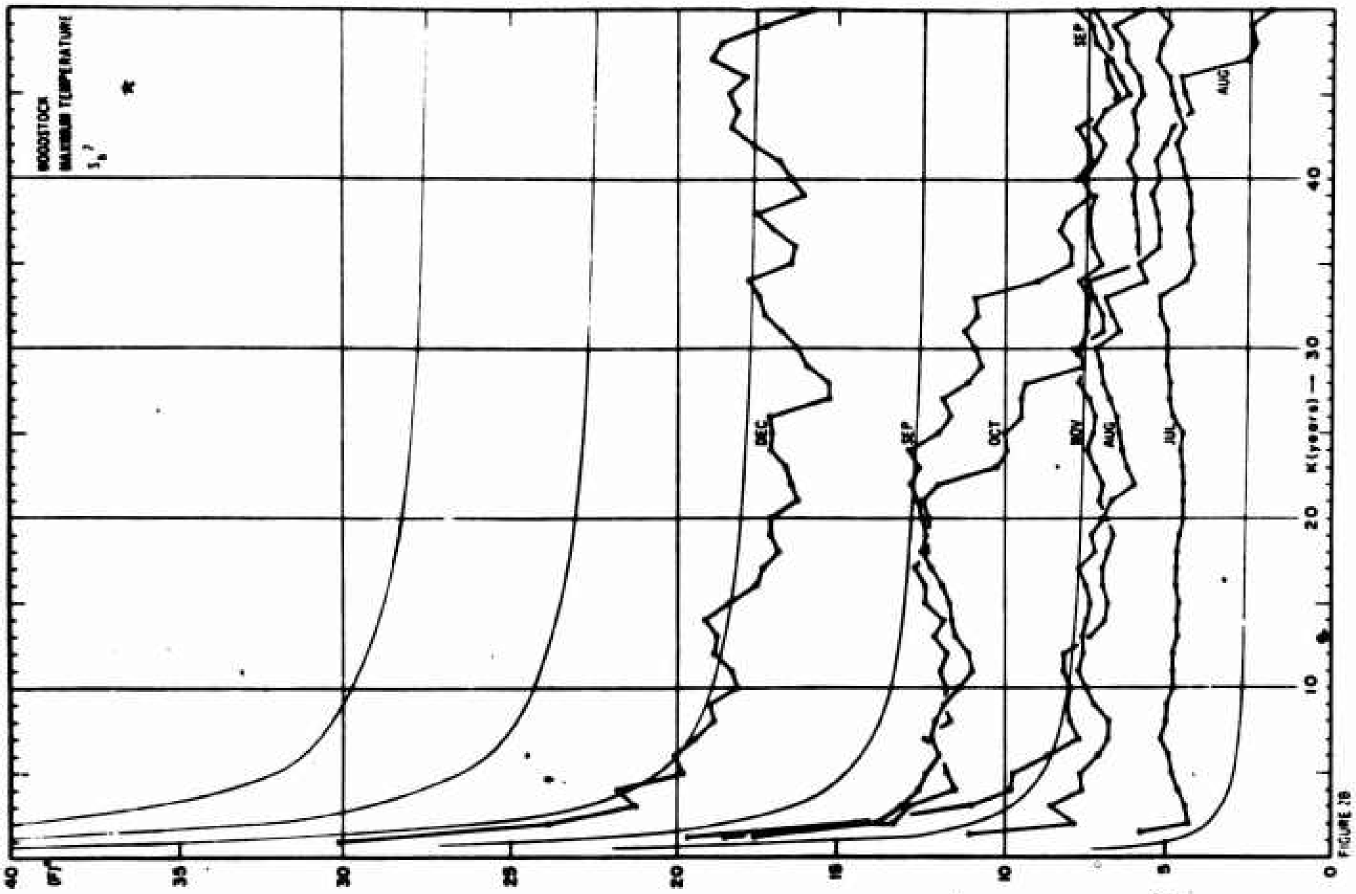


FIGURE 2B

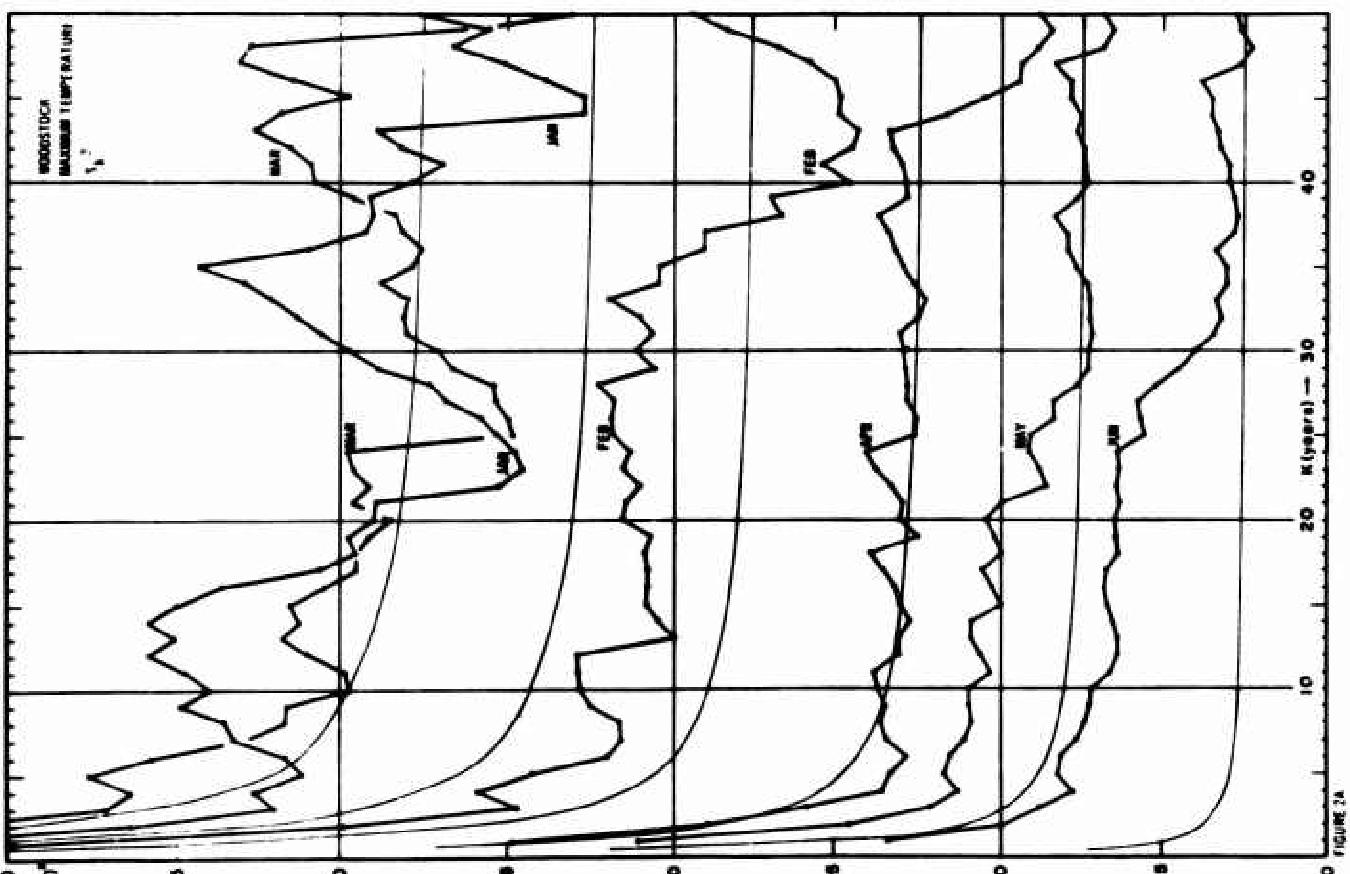


FIGURE 2A

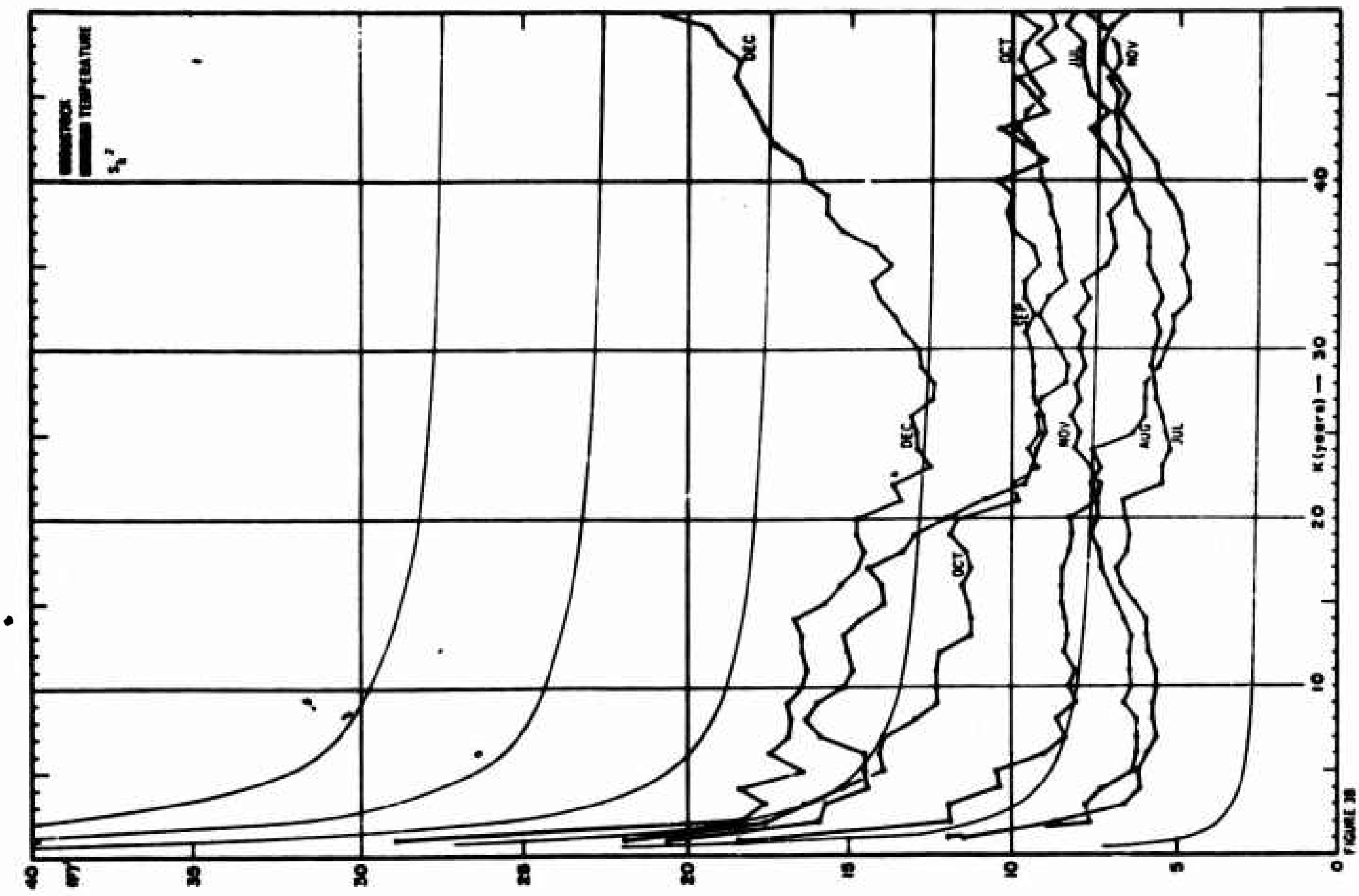


FIGURE 3B

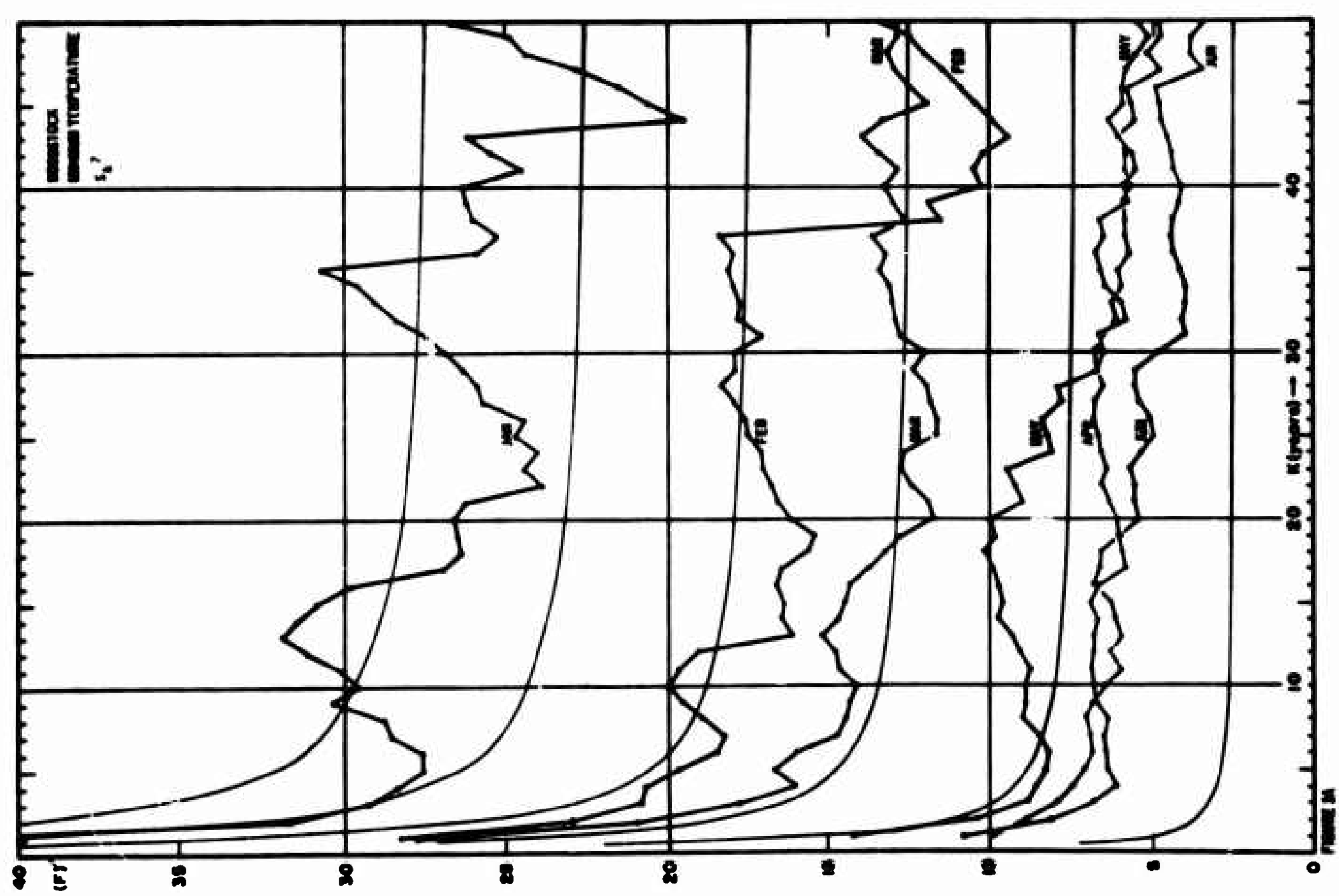


FIGURE 3A

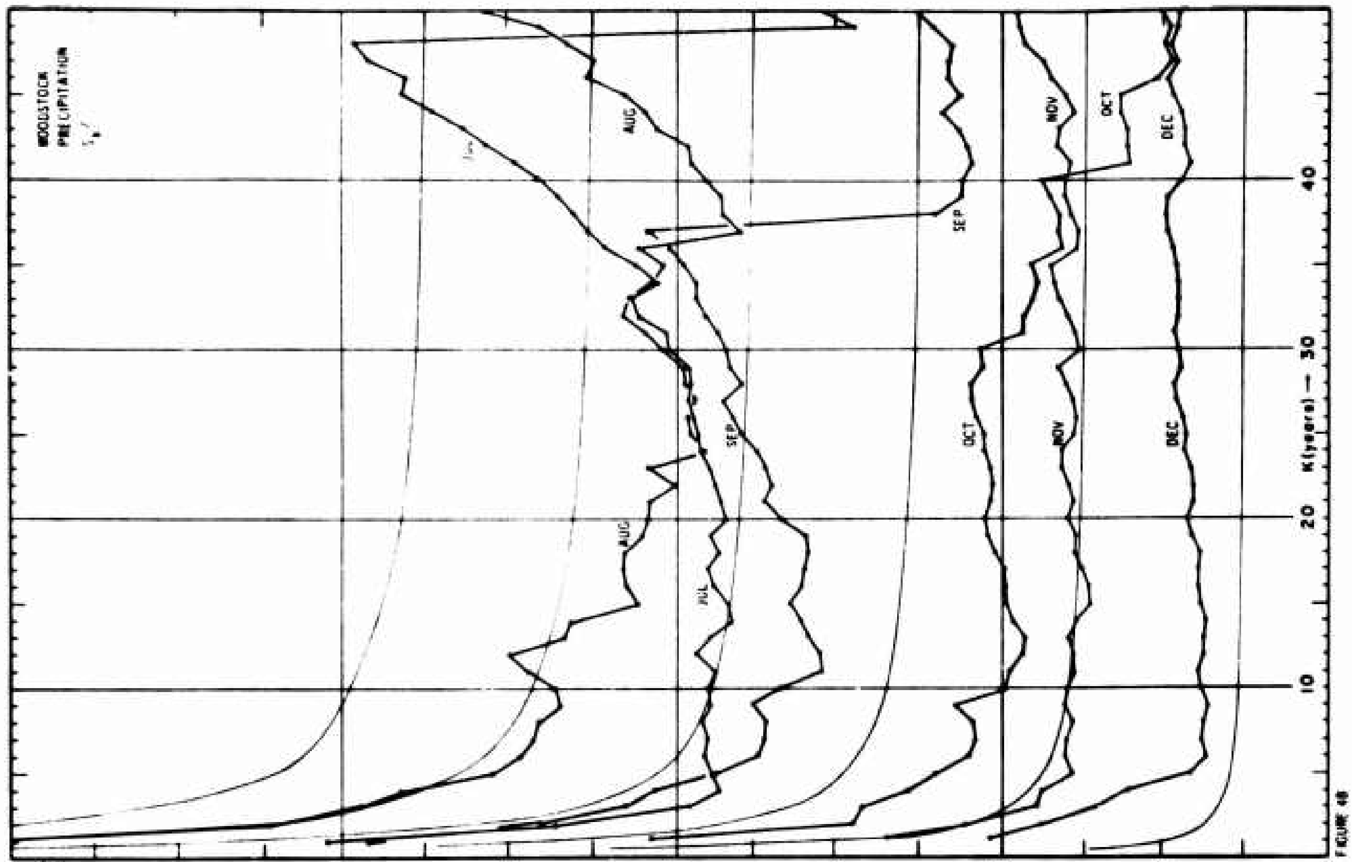


FIGURE 4B

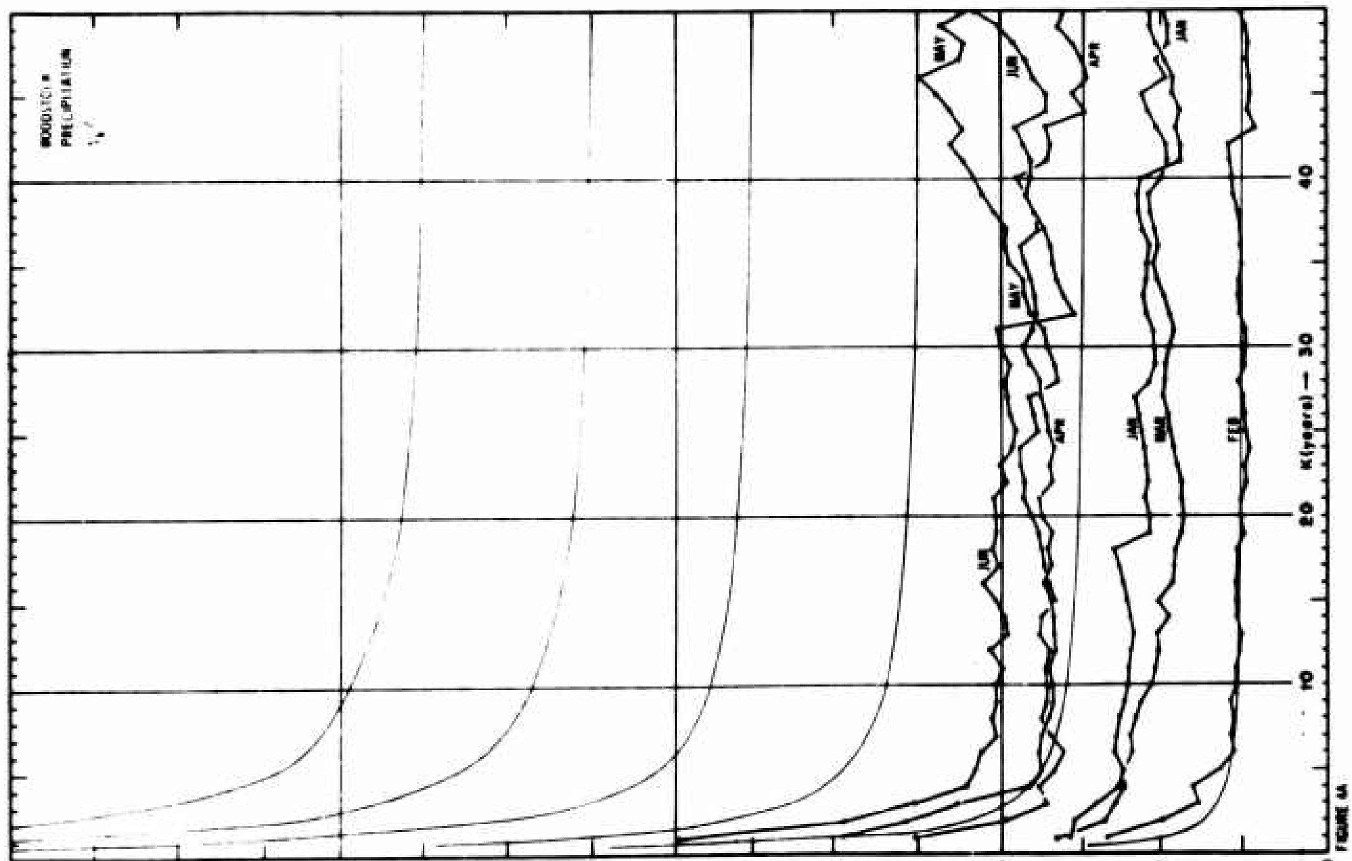


FIGURE 4A

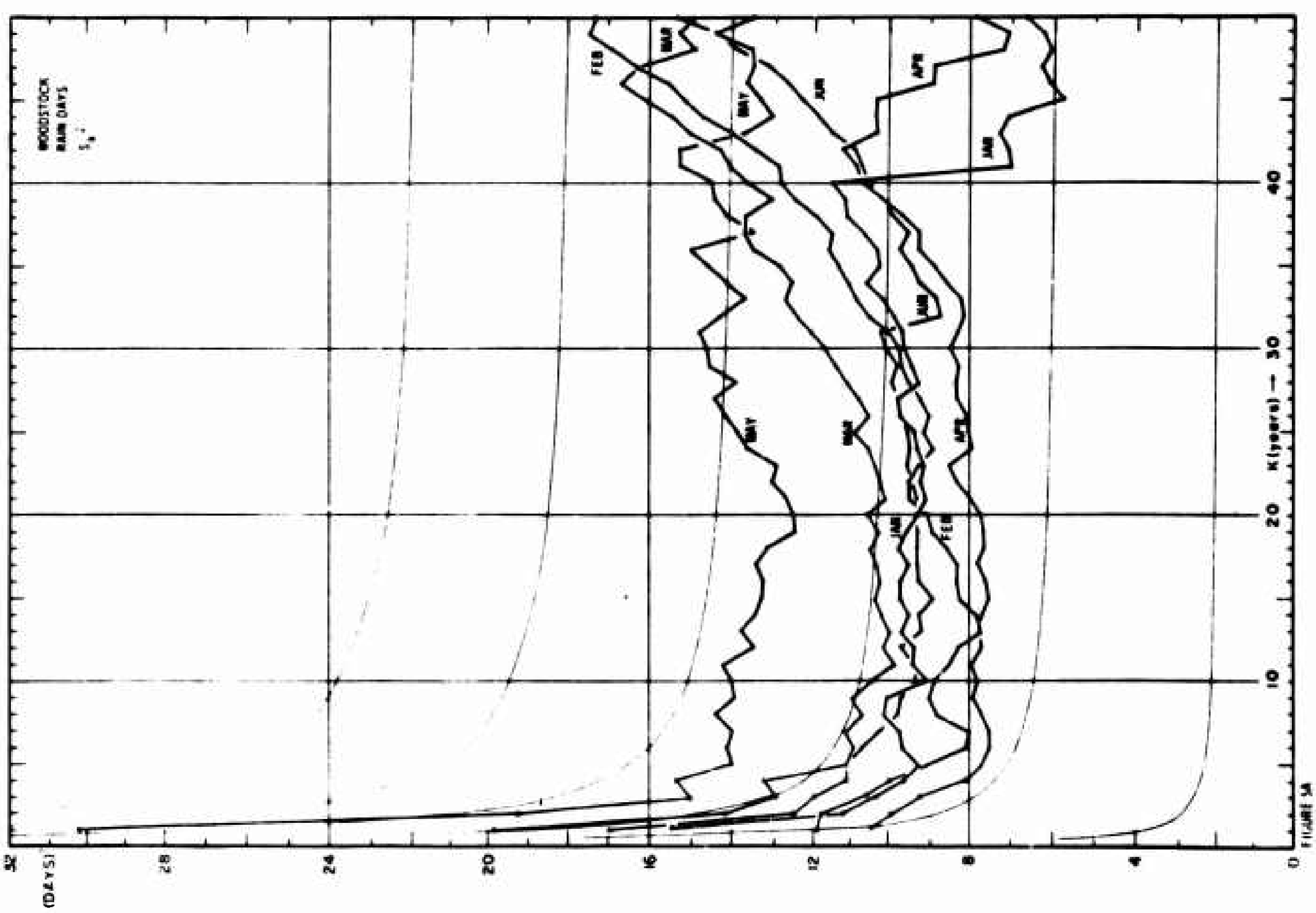


FIGURE 5A

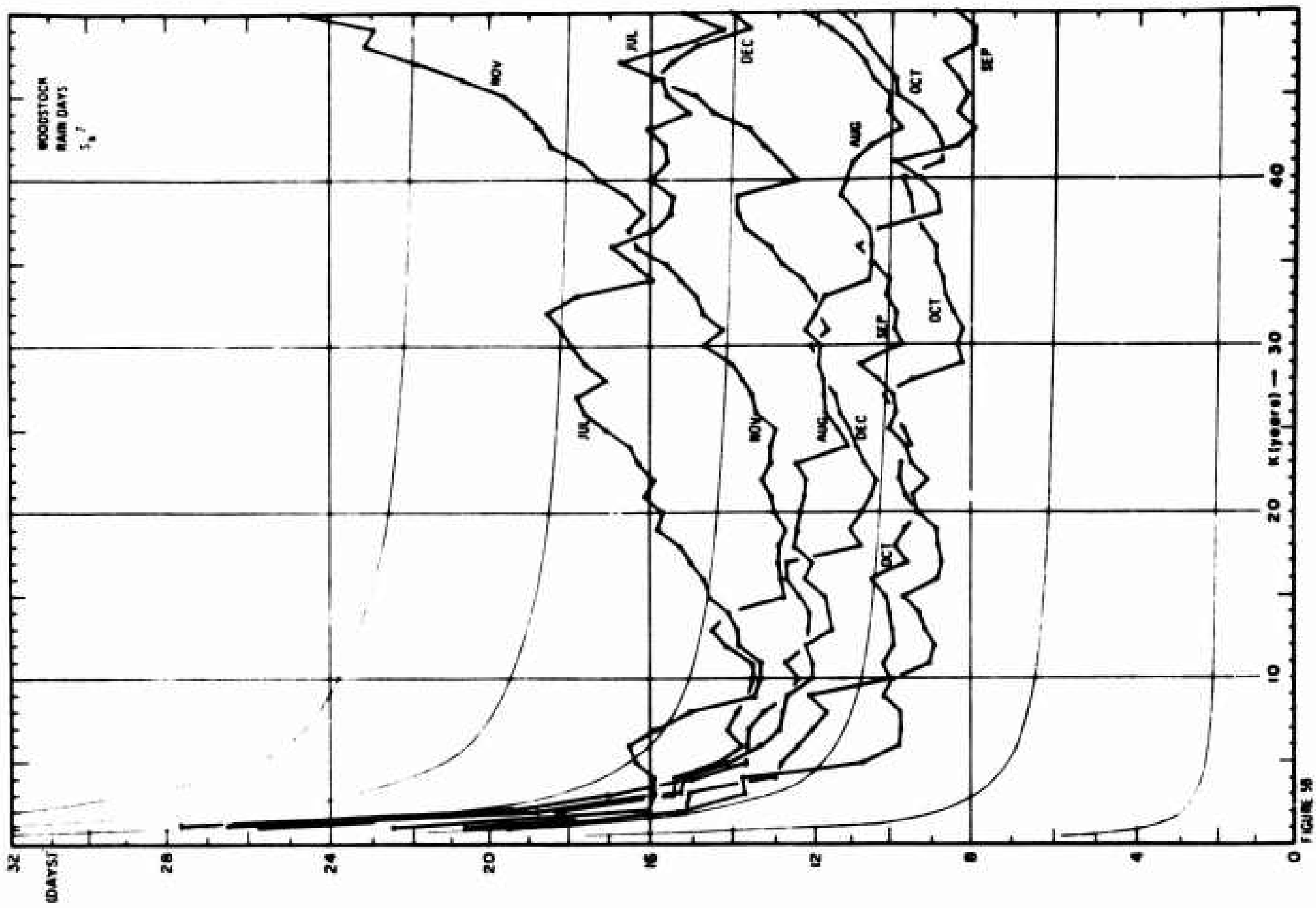
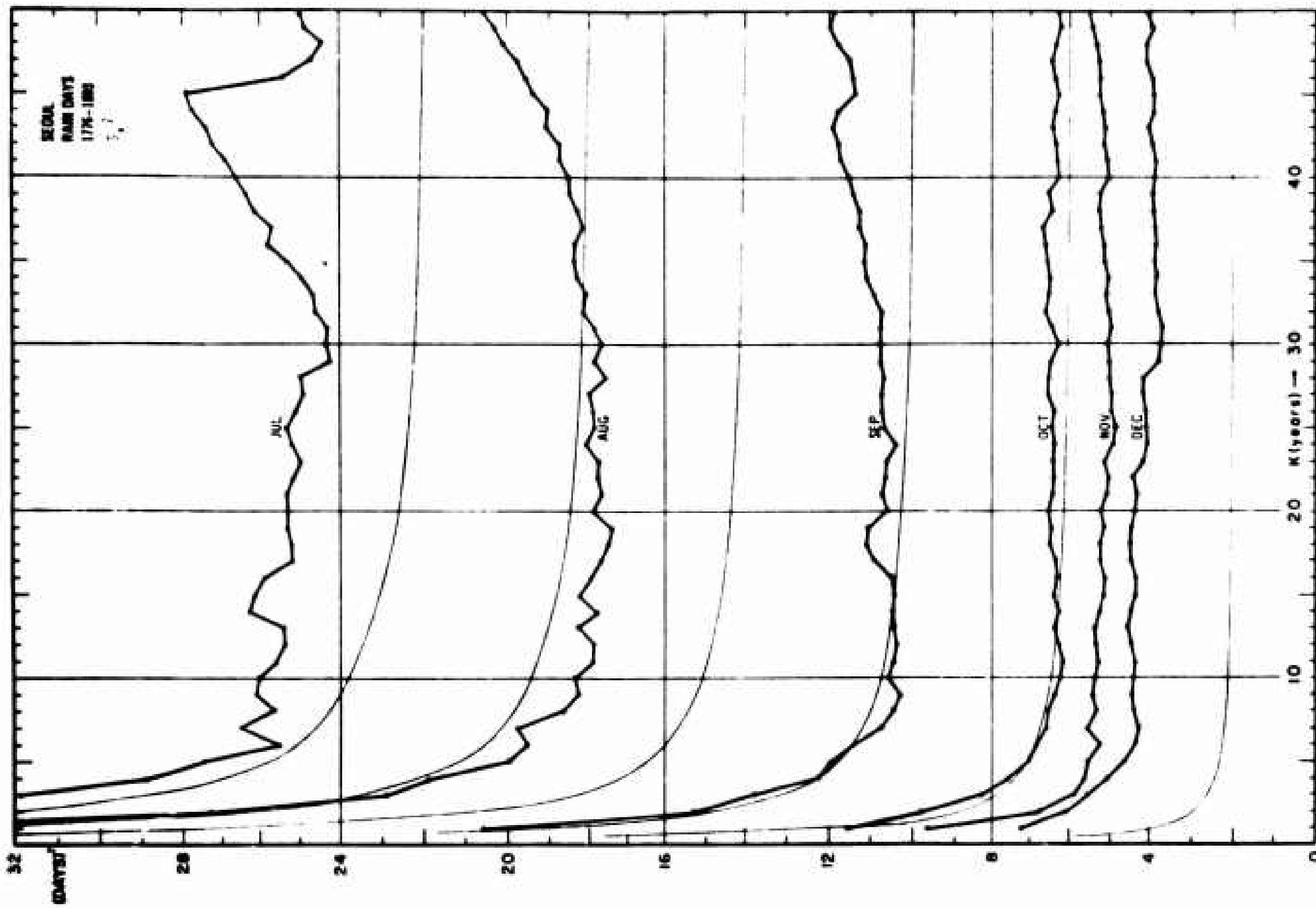
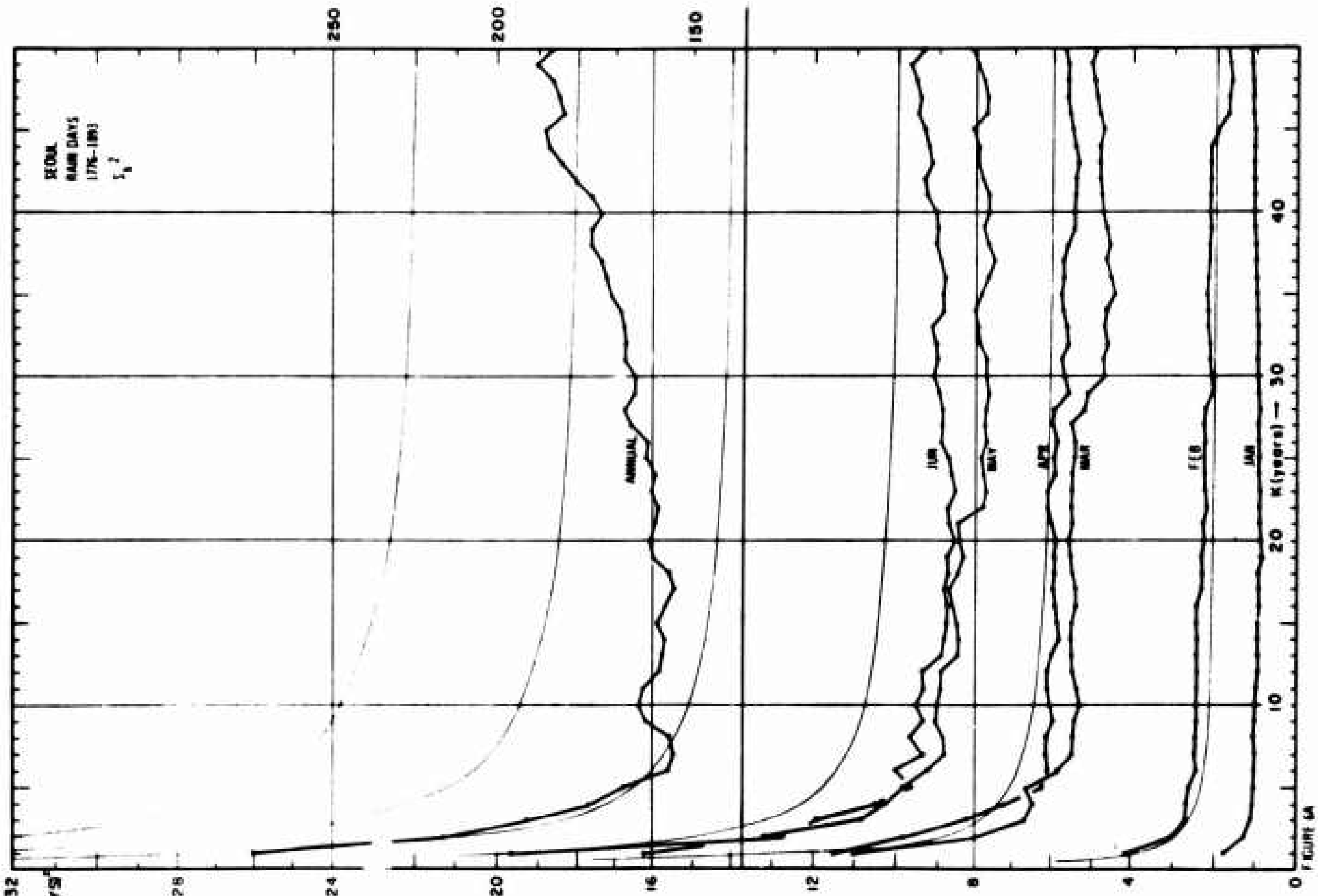


FIGURE 5B


SEOUL
RAIN DAYS
JUL
AUG
SEP
OCT
NOV
DEC
K (years)
FIGURE 6B


SEOUL
RAIN DAYS
ANNUAL
JUN
MAY
APR
MAR
FEB
JAN
K (years)
FIGURE 6A

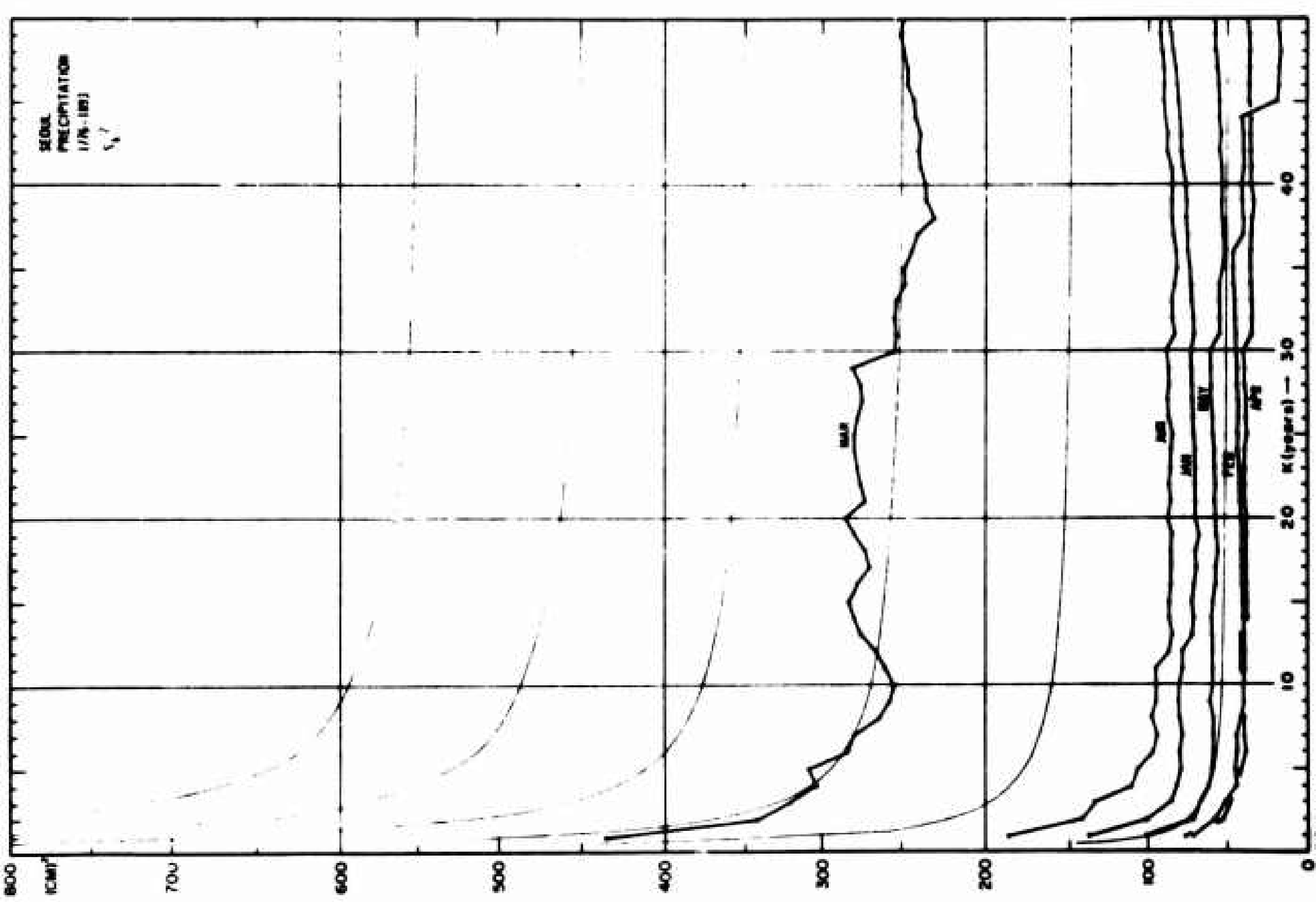


FIGURE 7A

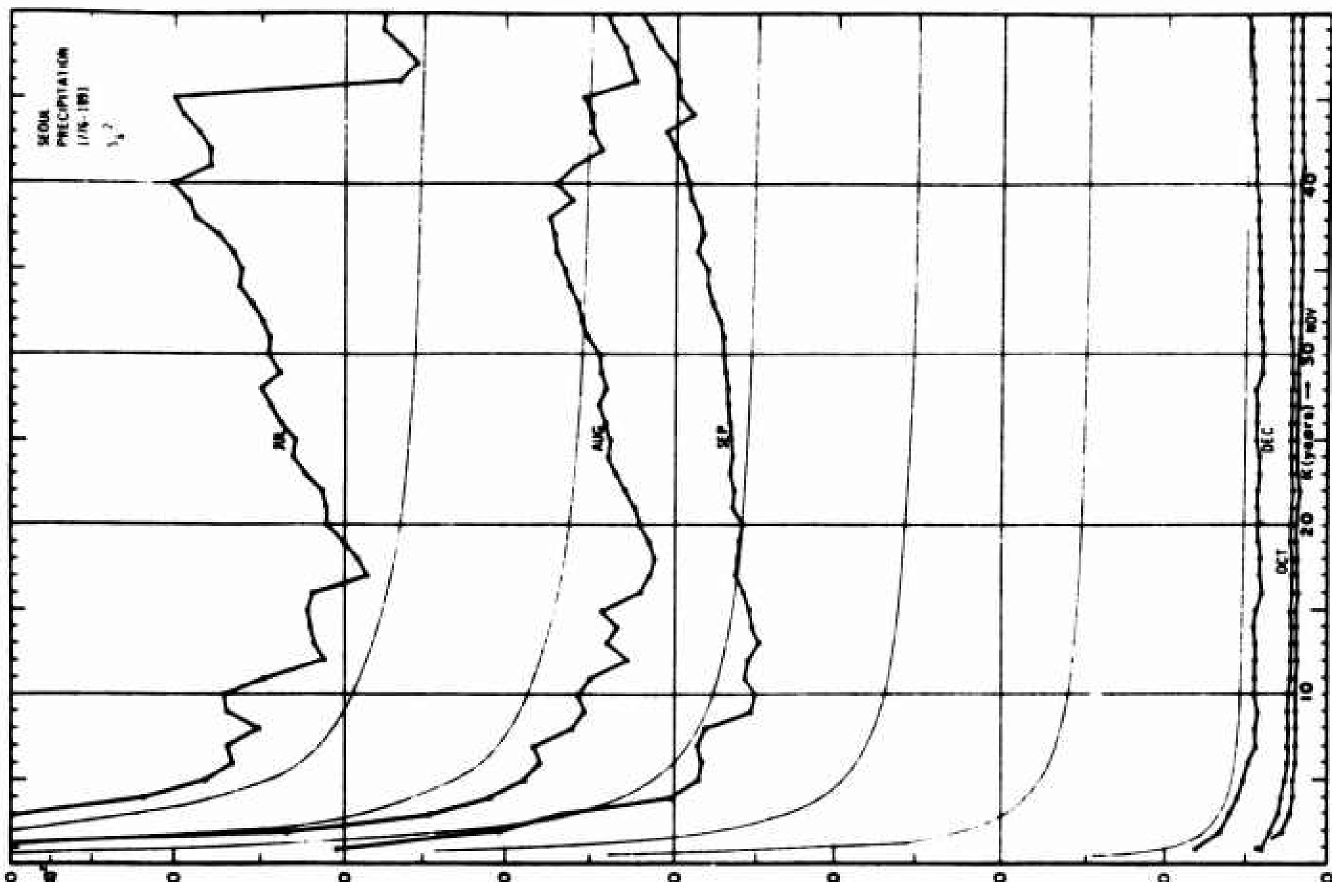


FIGURE 7B

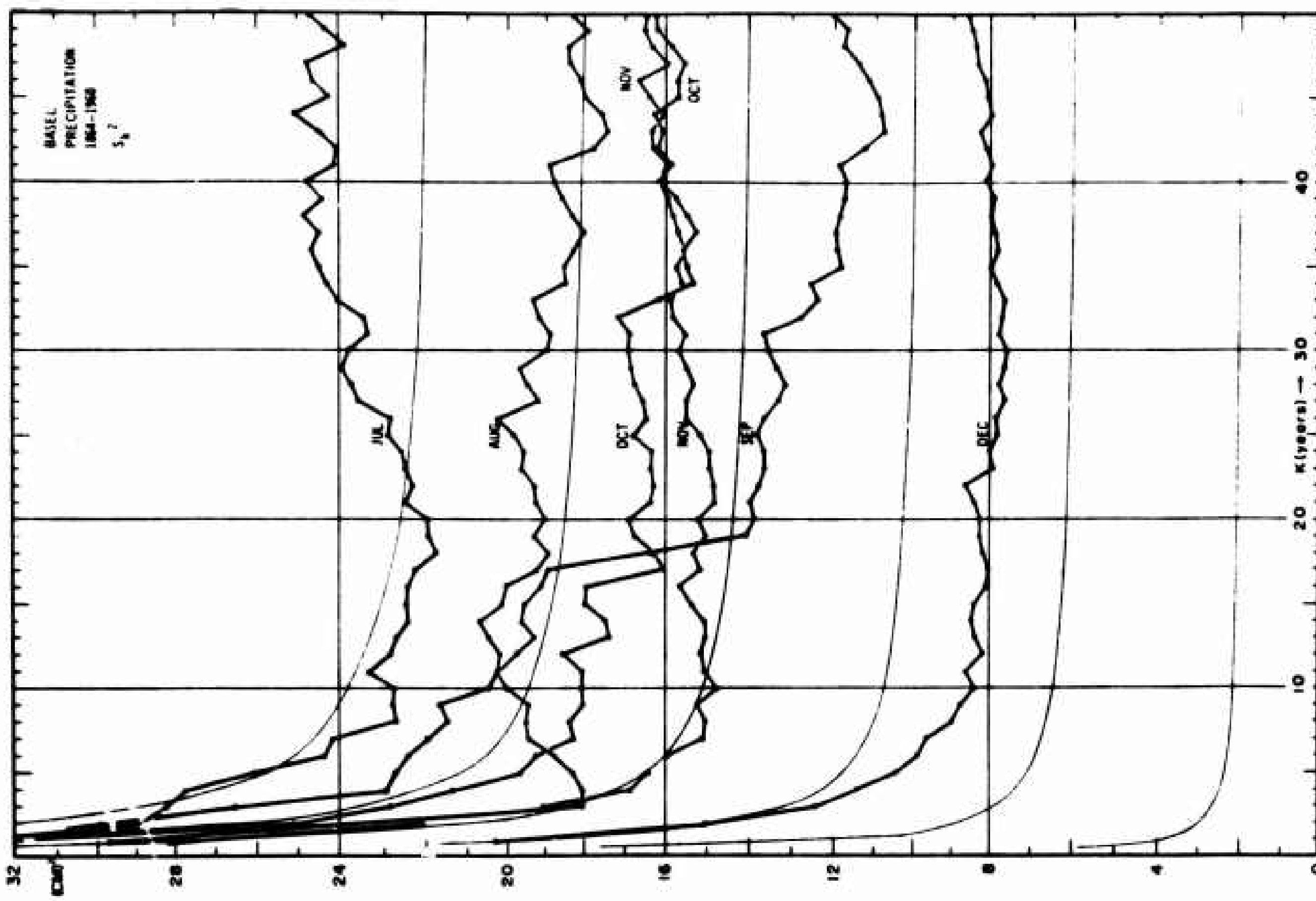


FIGURE 8B

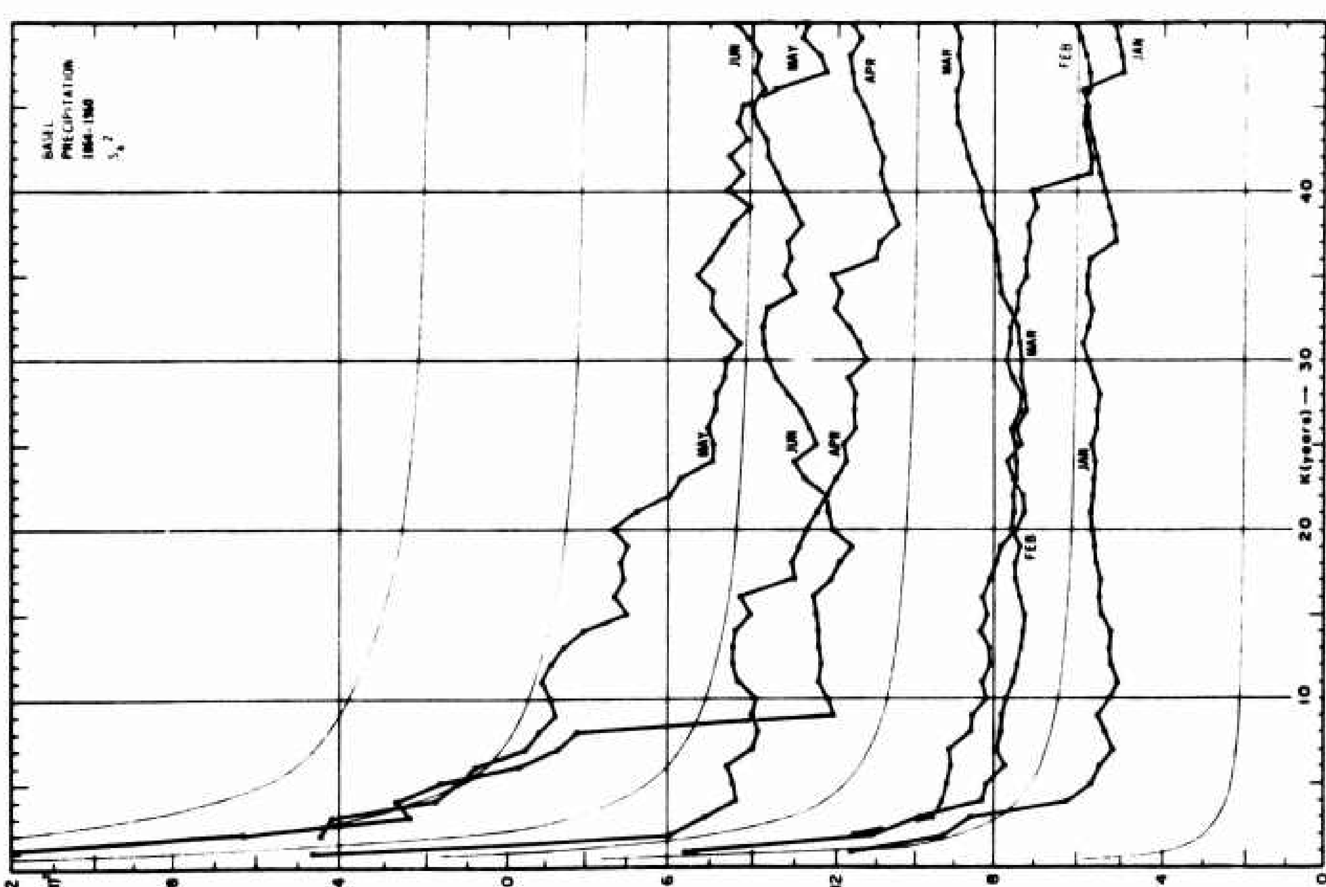


FIGURE 8A

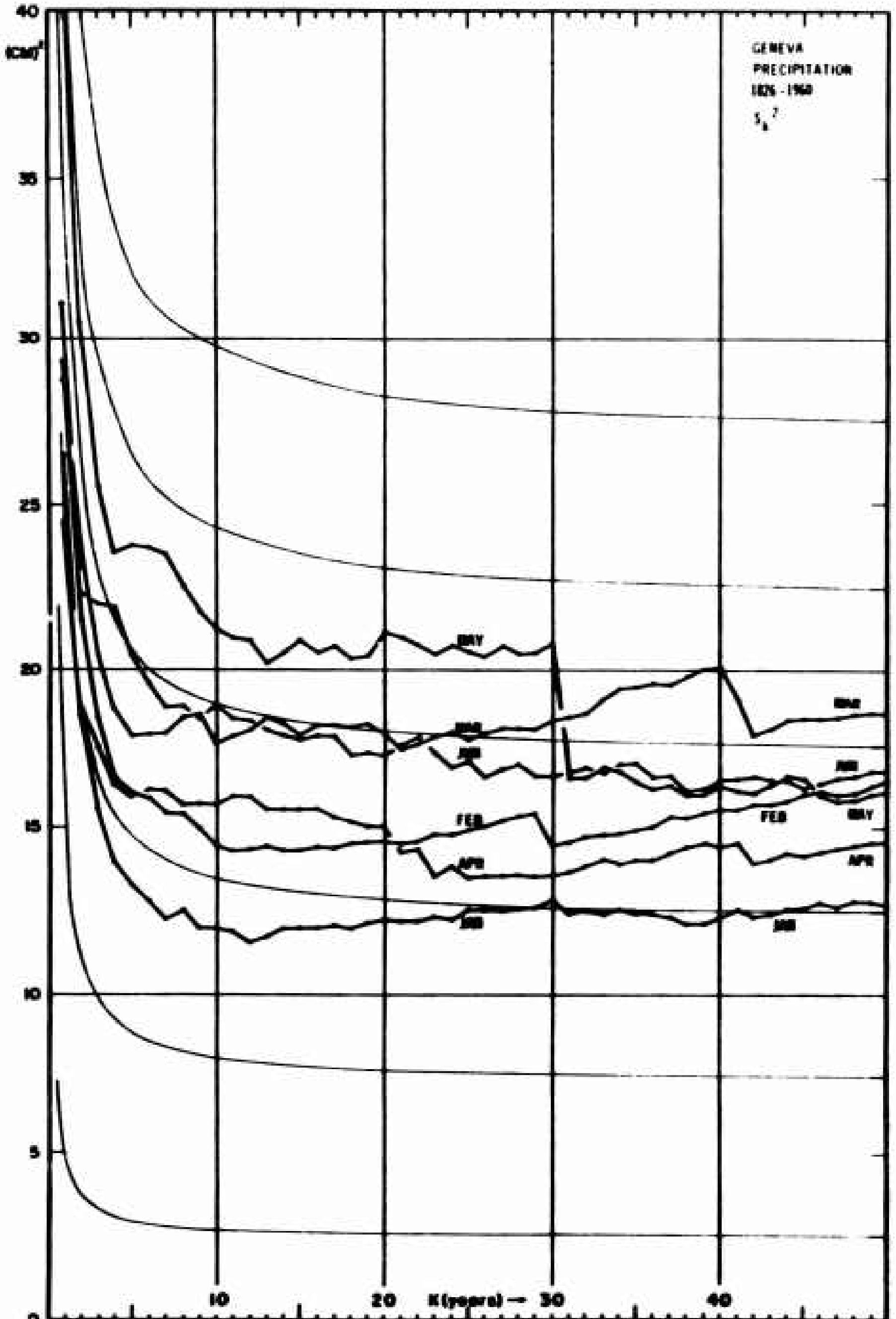


FIGURE 9A

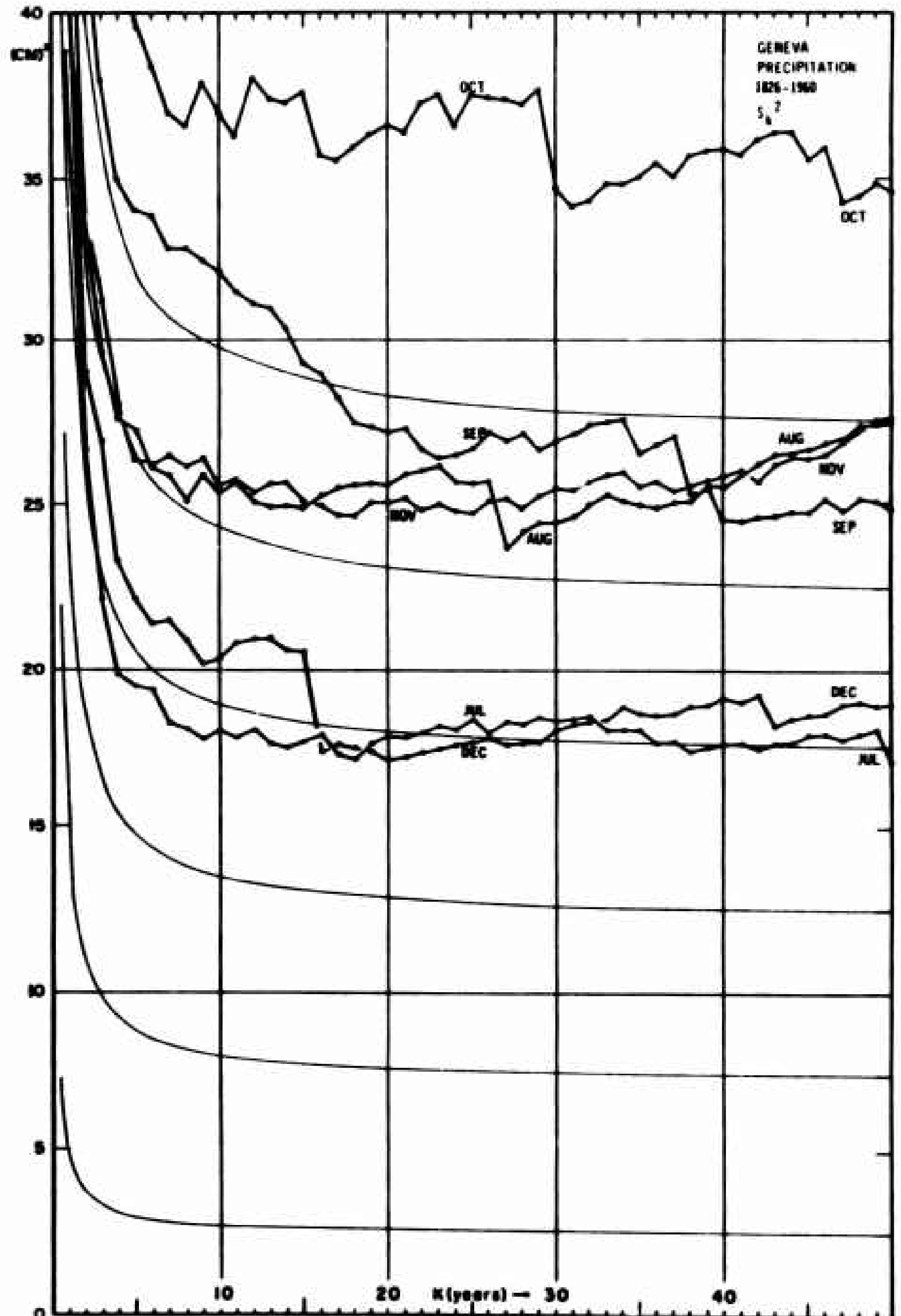
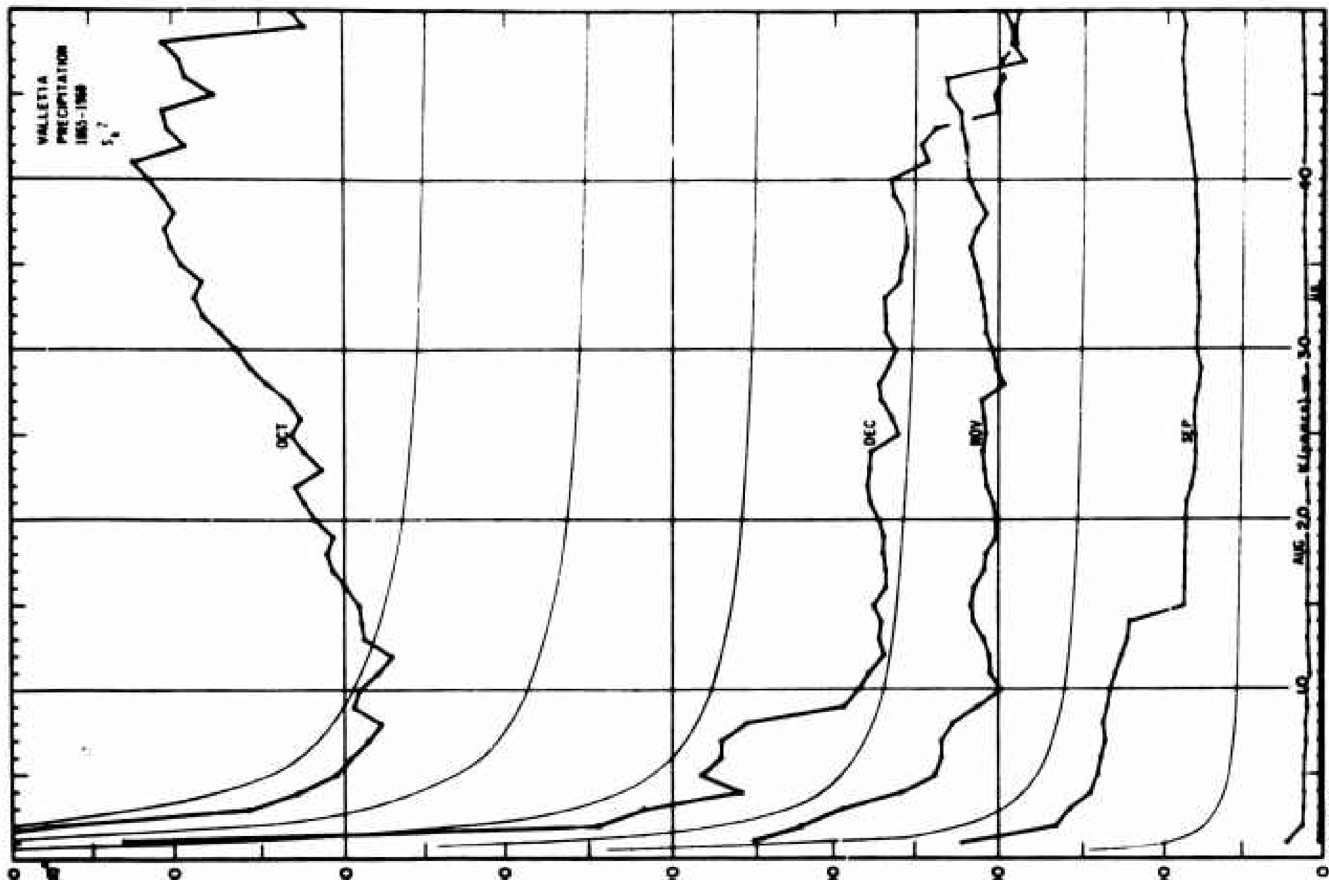
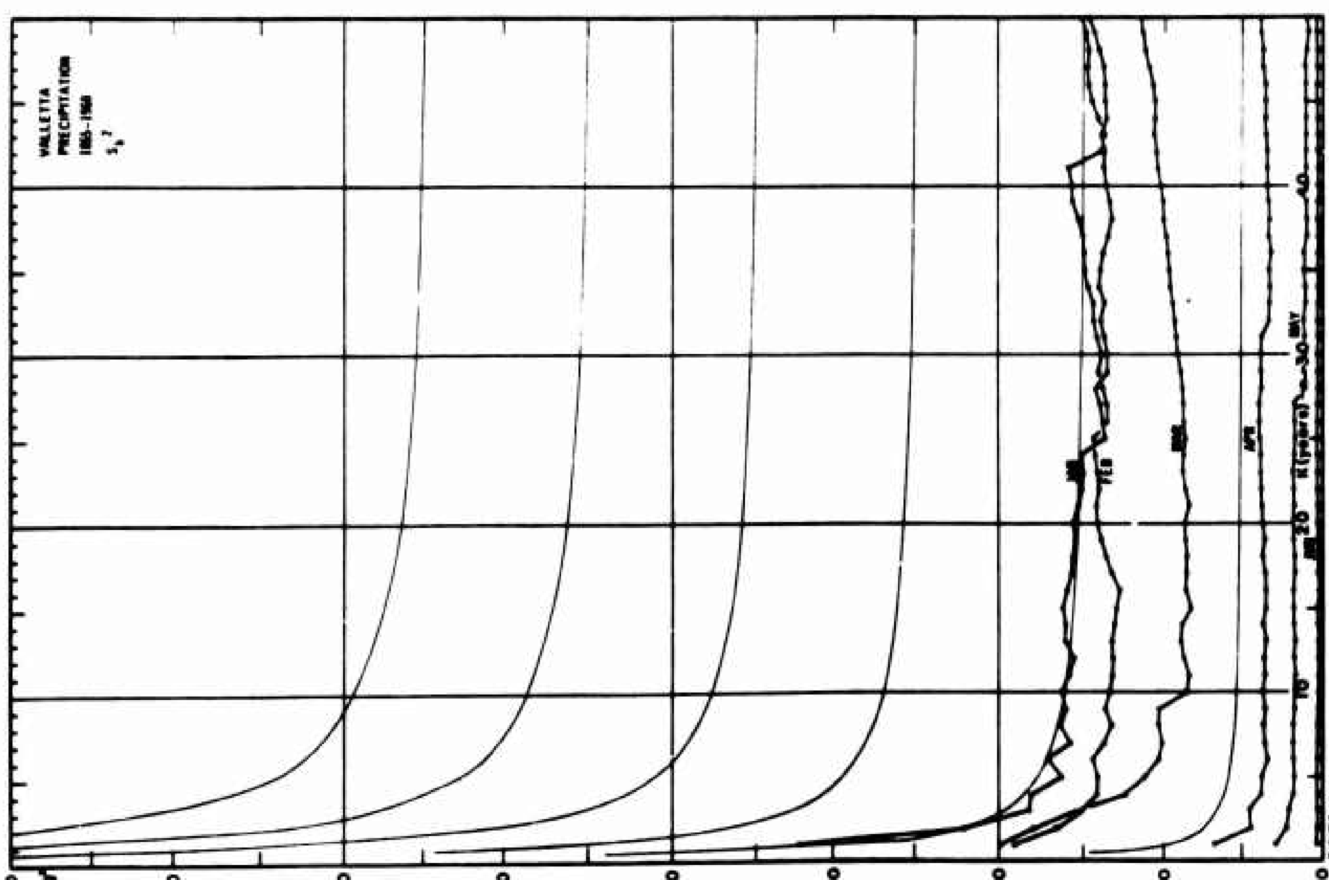
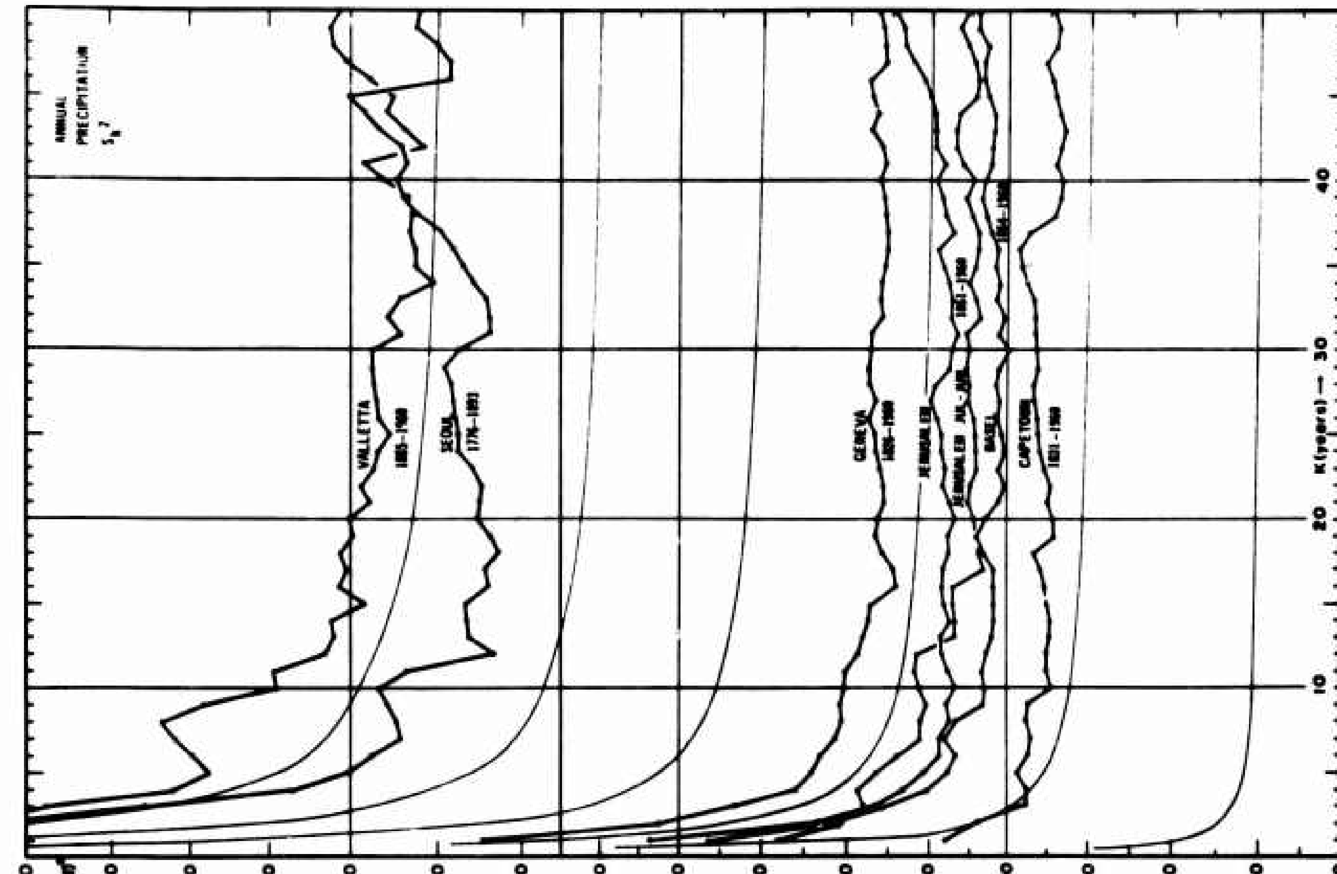
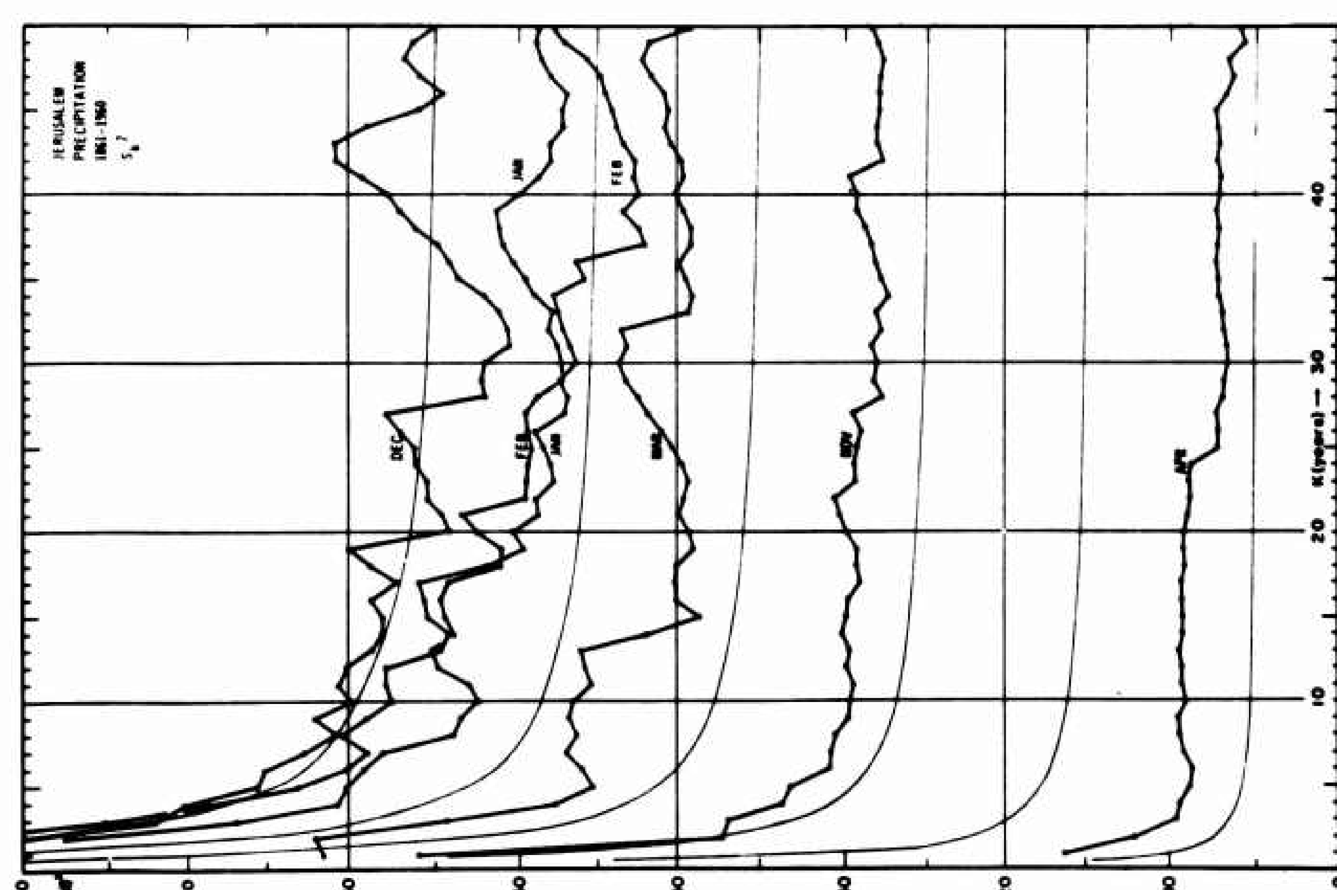


FIGURE 9B


VALLETTA
PRECIPITATION
OCT
DEC
NOV
SEP
AUG


VALLETTA
PRECIPITATION
FEB
APR
MAY


ANNUAL PRECIPITATION
VALLETTA
1885-1960
SEOUL
1776-1891
GENEVA
JERUSALEM
BASEL
CAPETOWN
K(years) →
FIGURE 11B


JERUSALEM PRECIPITATION
1861-1960
DEC
JAN
FEB
MAR
NOV
APR
K(years) →
FIGURE 11A

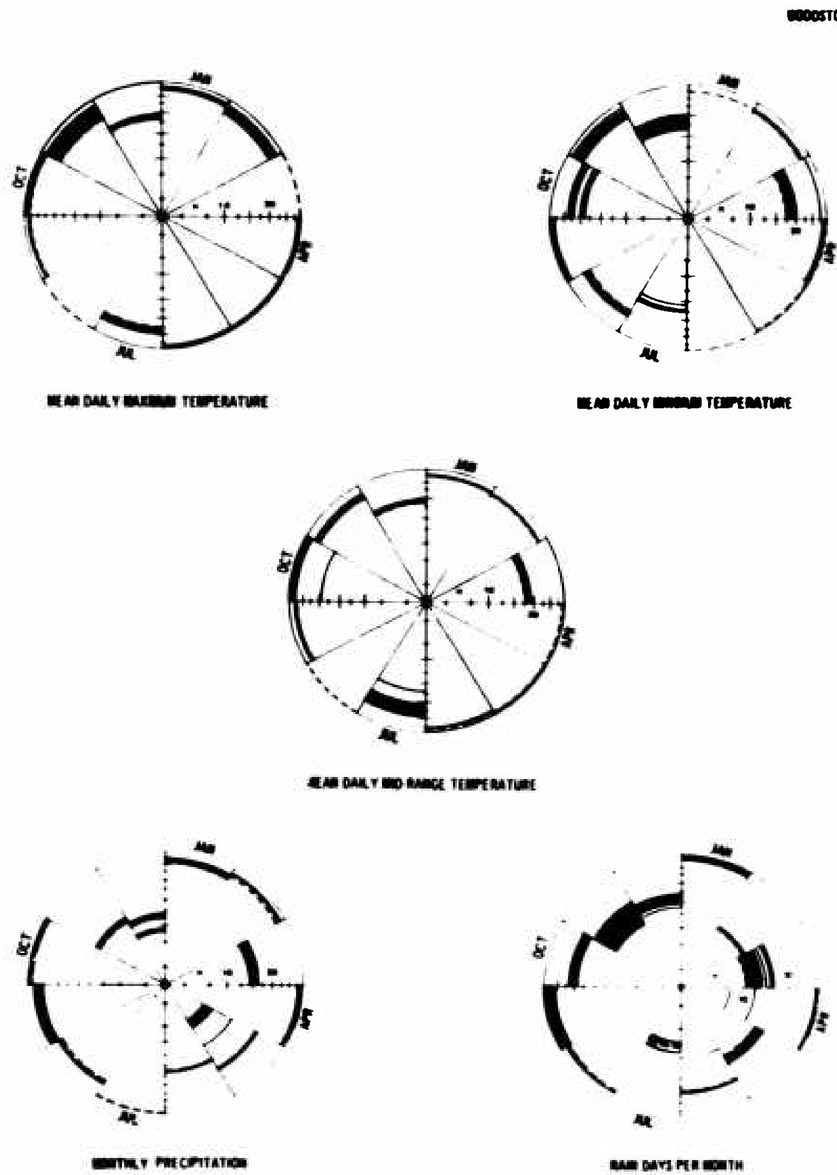


FIGURE 12A

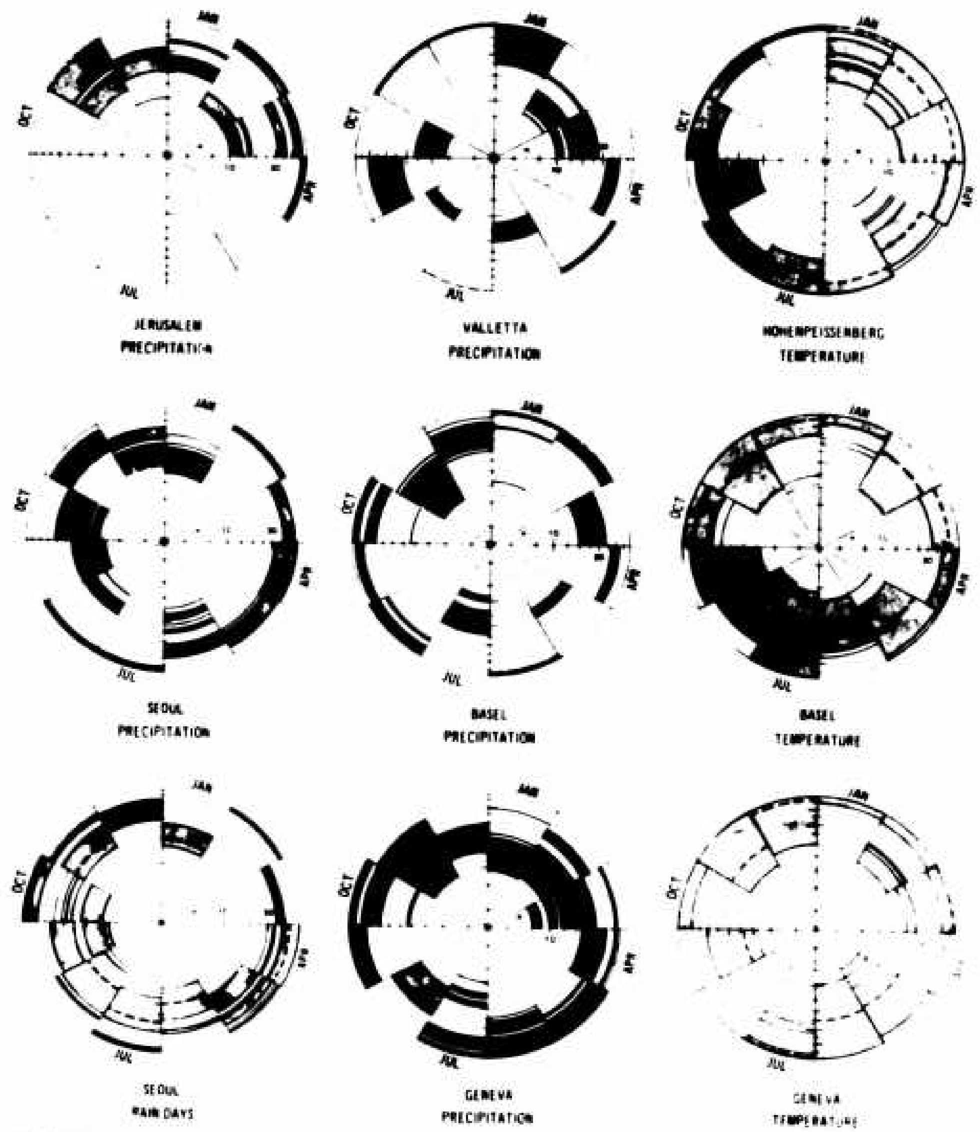


FIGURE 12B

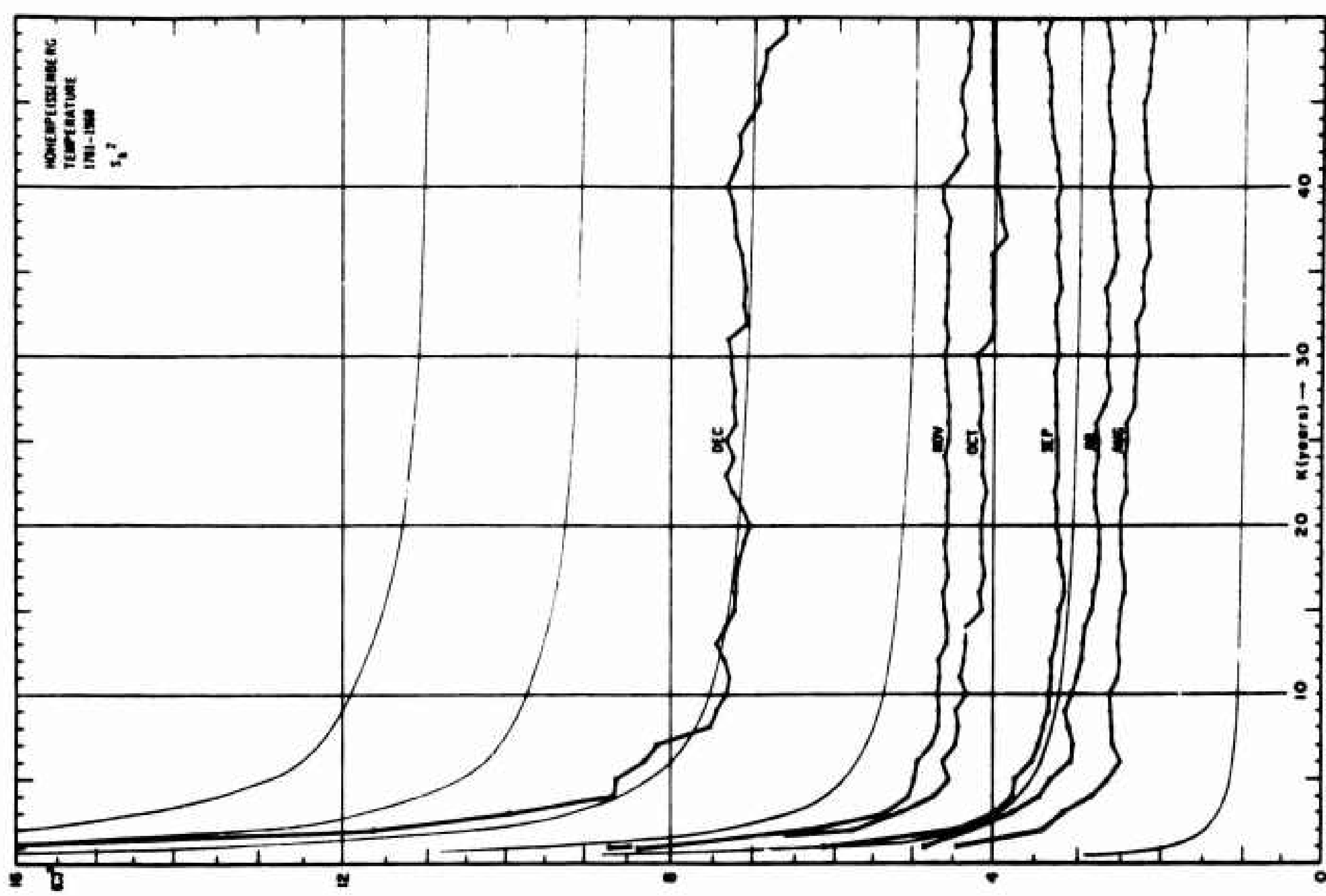


FIGURE 13B

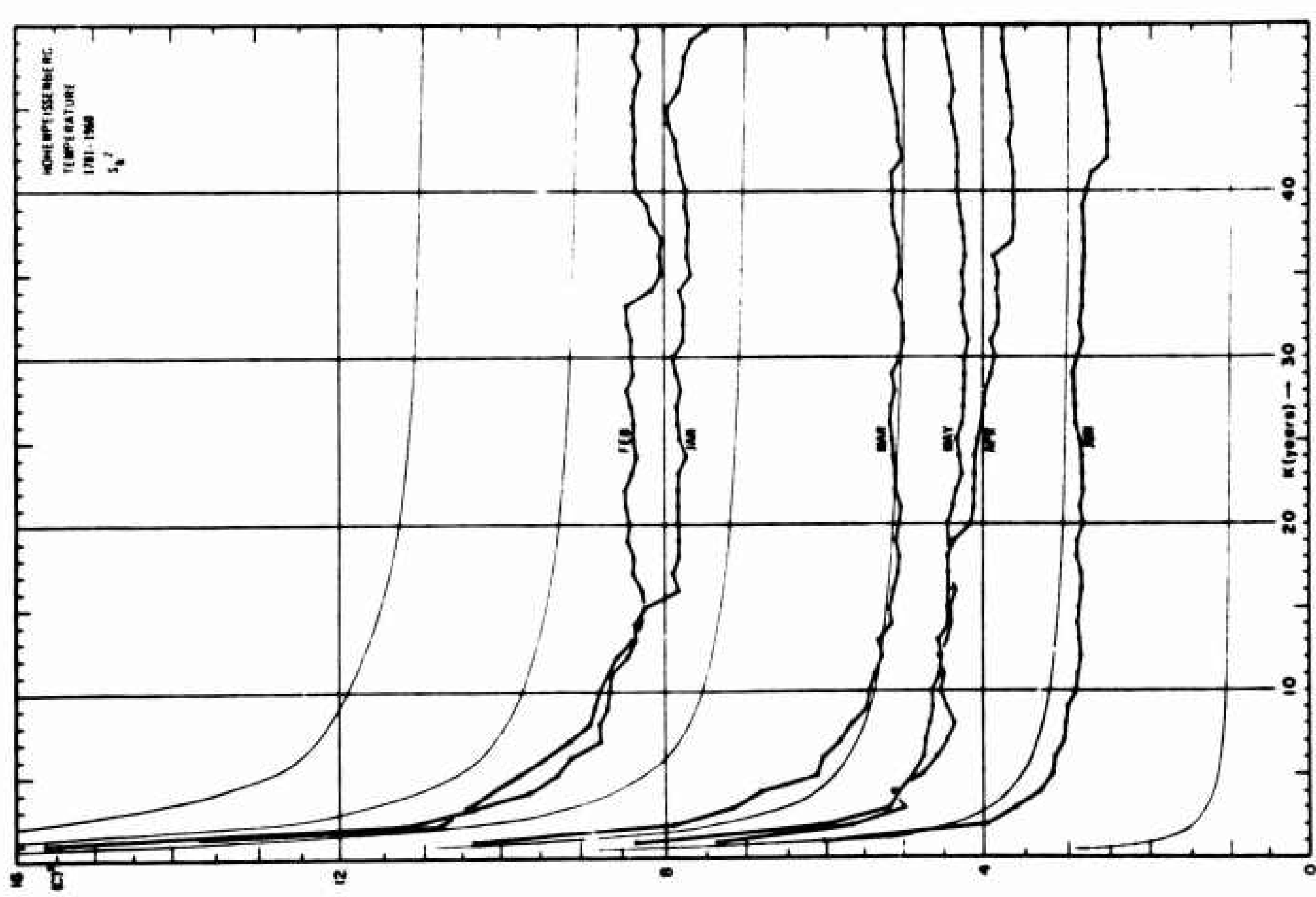
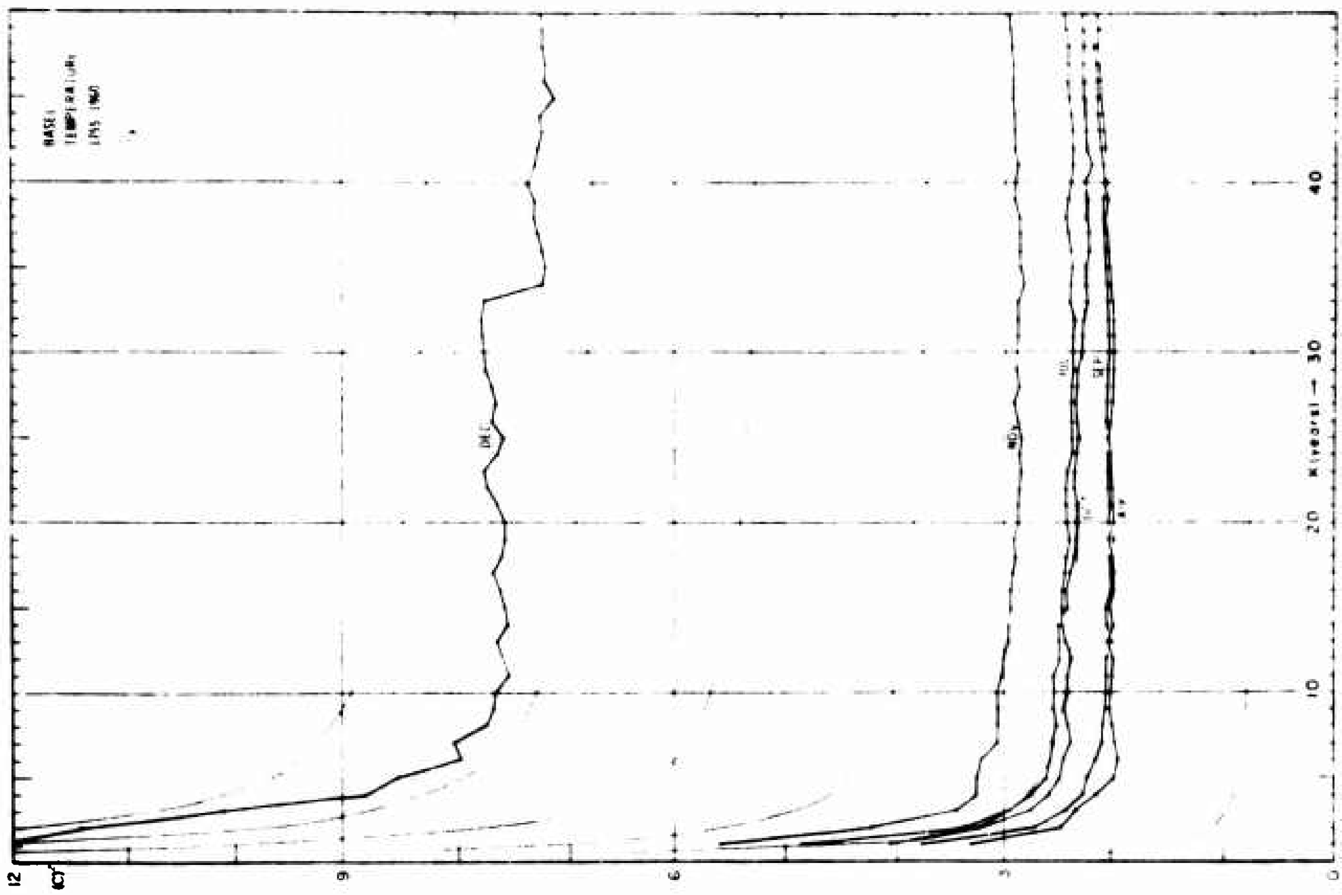
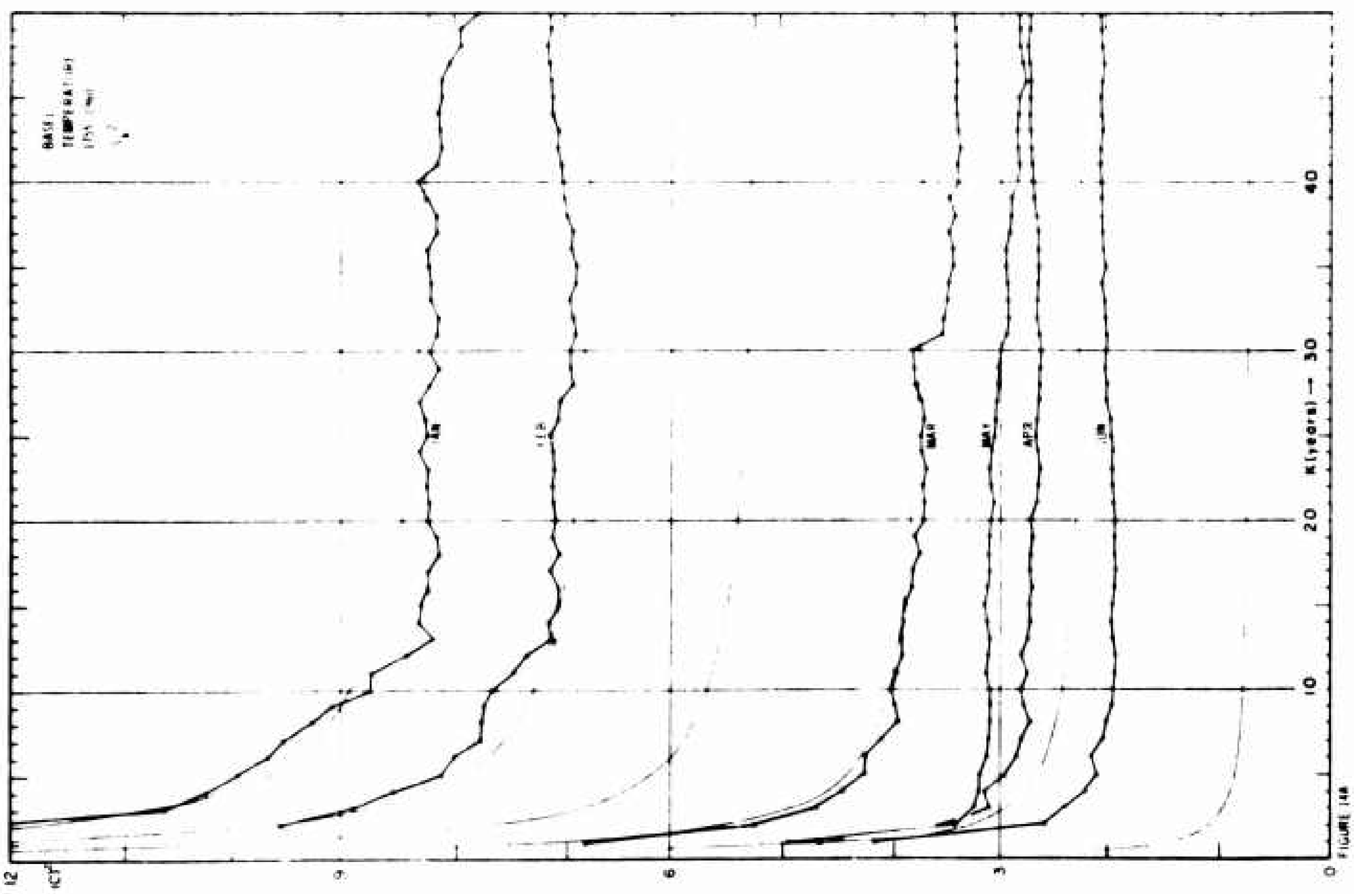


FIGURE 13A


12
9
6
3
0
10
20
30
40
K(years) →
DEC
NOV
SEP


12
9
6
3
0
10
20
30
40
K(years) →
JAN
FEB
MAR
MAY
APR
JUN
FIGURE 14A

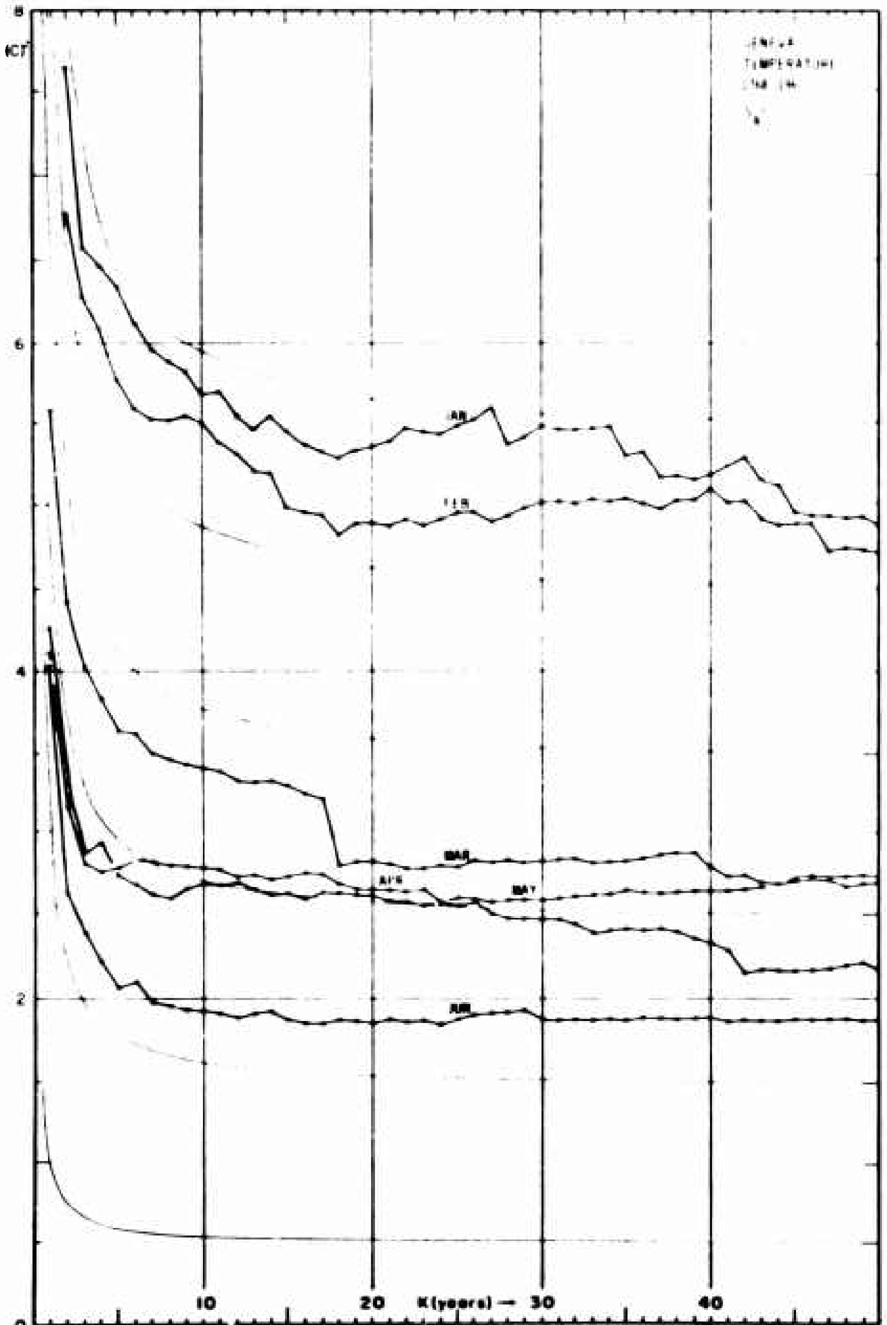


FIGURE 15A

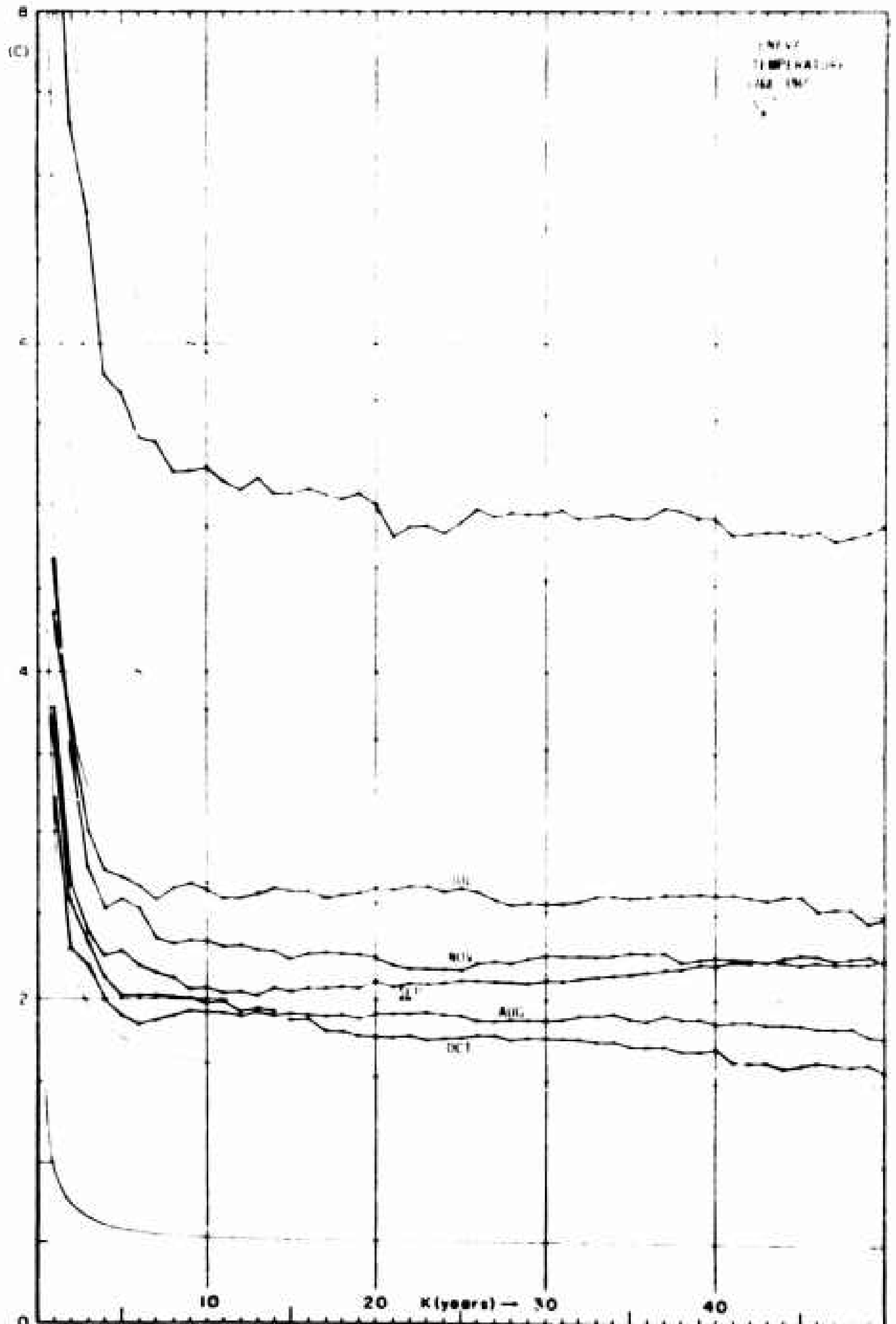
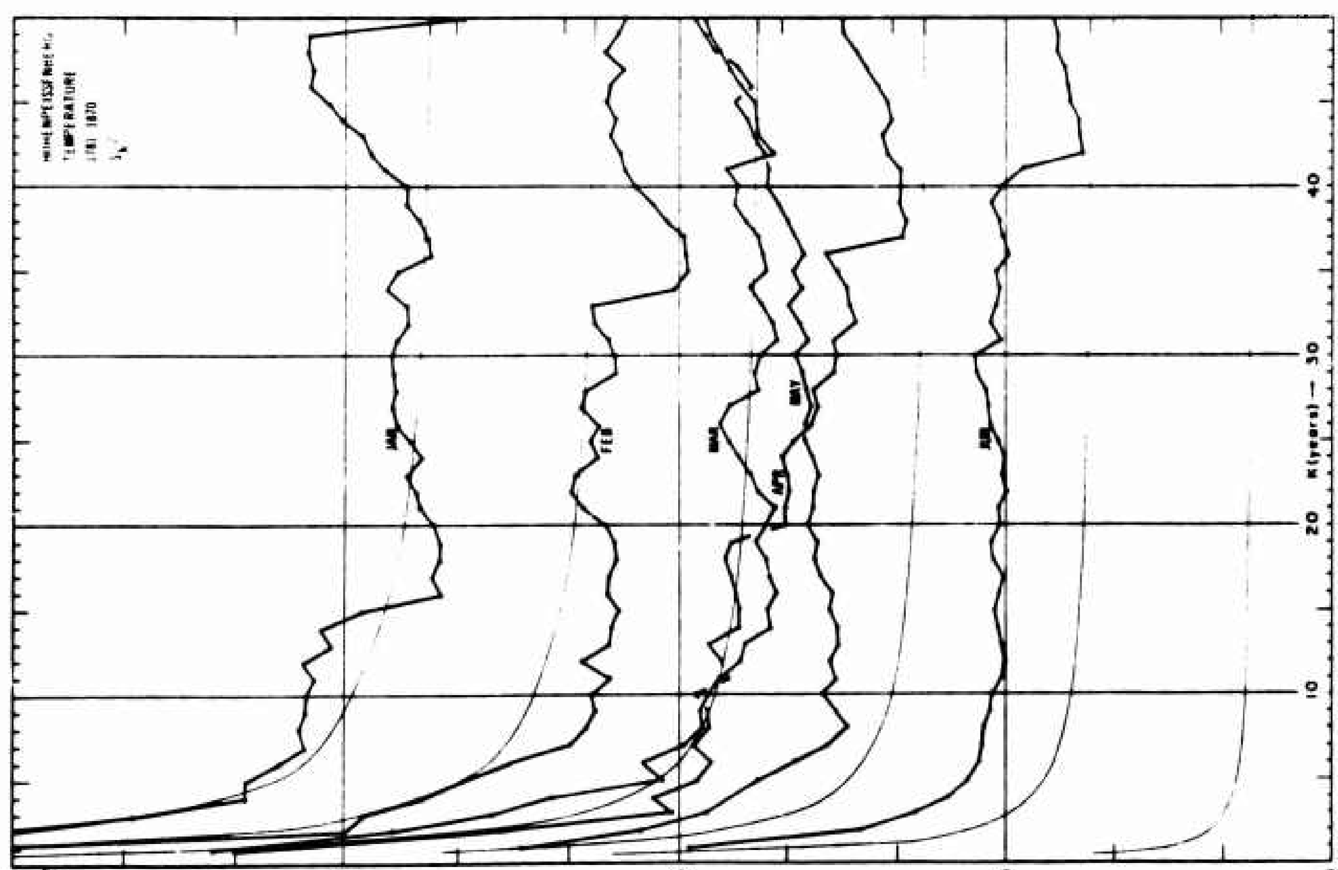
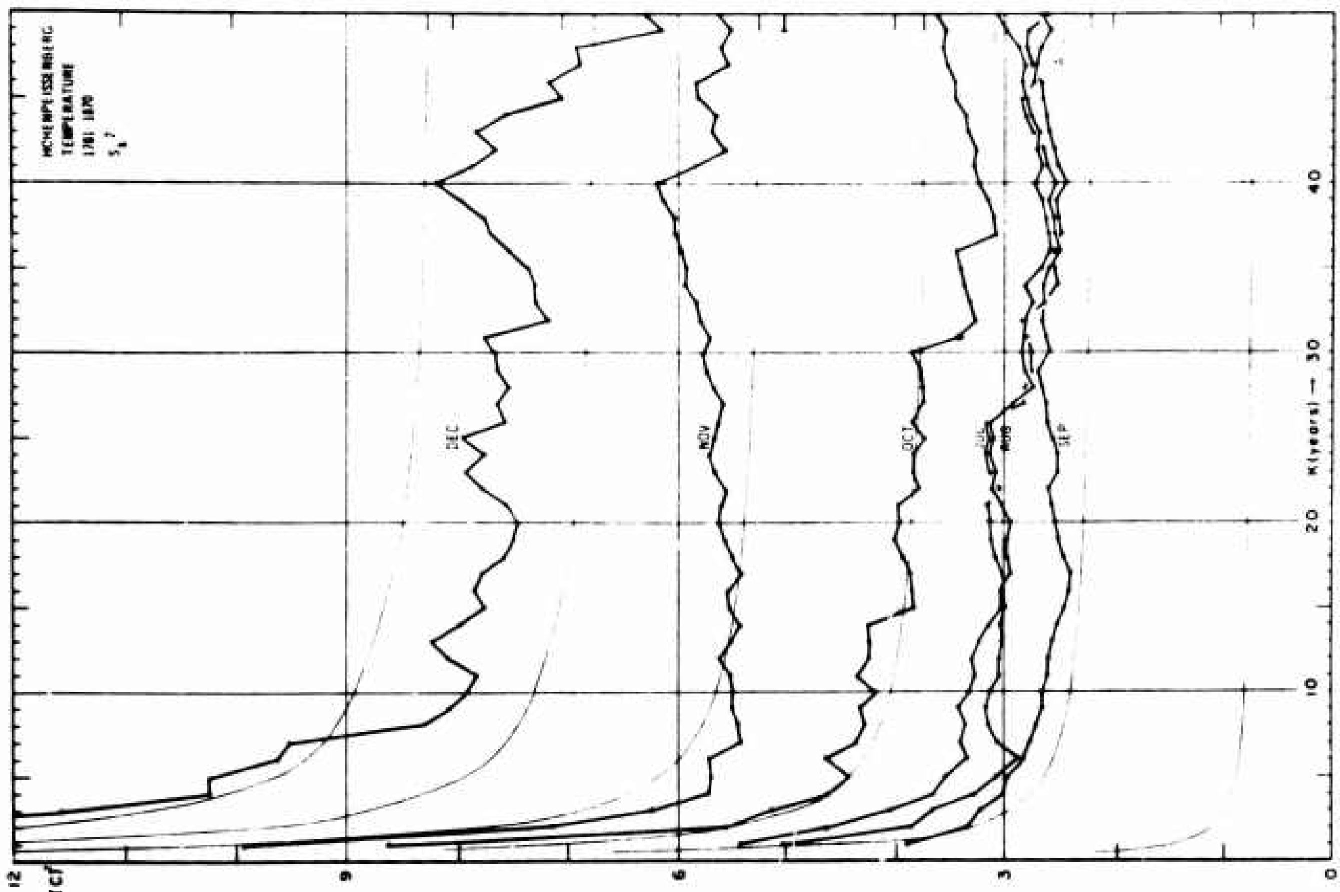


FIGURE 15B


HOHENPEISSENBERG
TEMPERATURE
1781 1870
JAN
FEB
MAR
APR
MAY
JUN
K(years)
(C)


HOHENPEISSENBERG
TEMPERATURE
1781 1870
DEC
NOV
OCT
JUL
AUG
SEP
K(years)
(C)

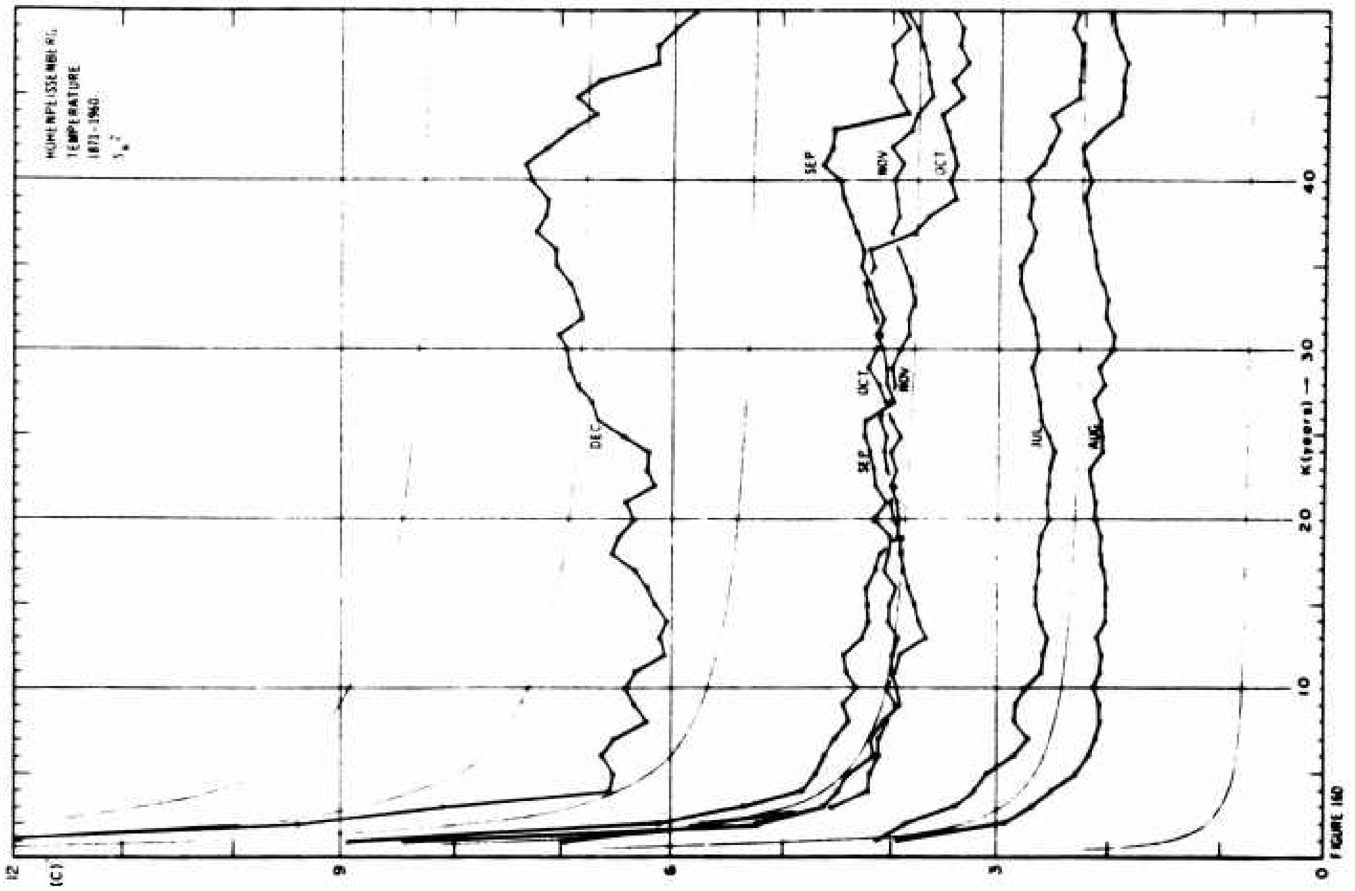


FIGURE 16D

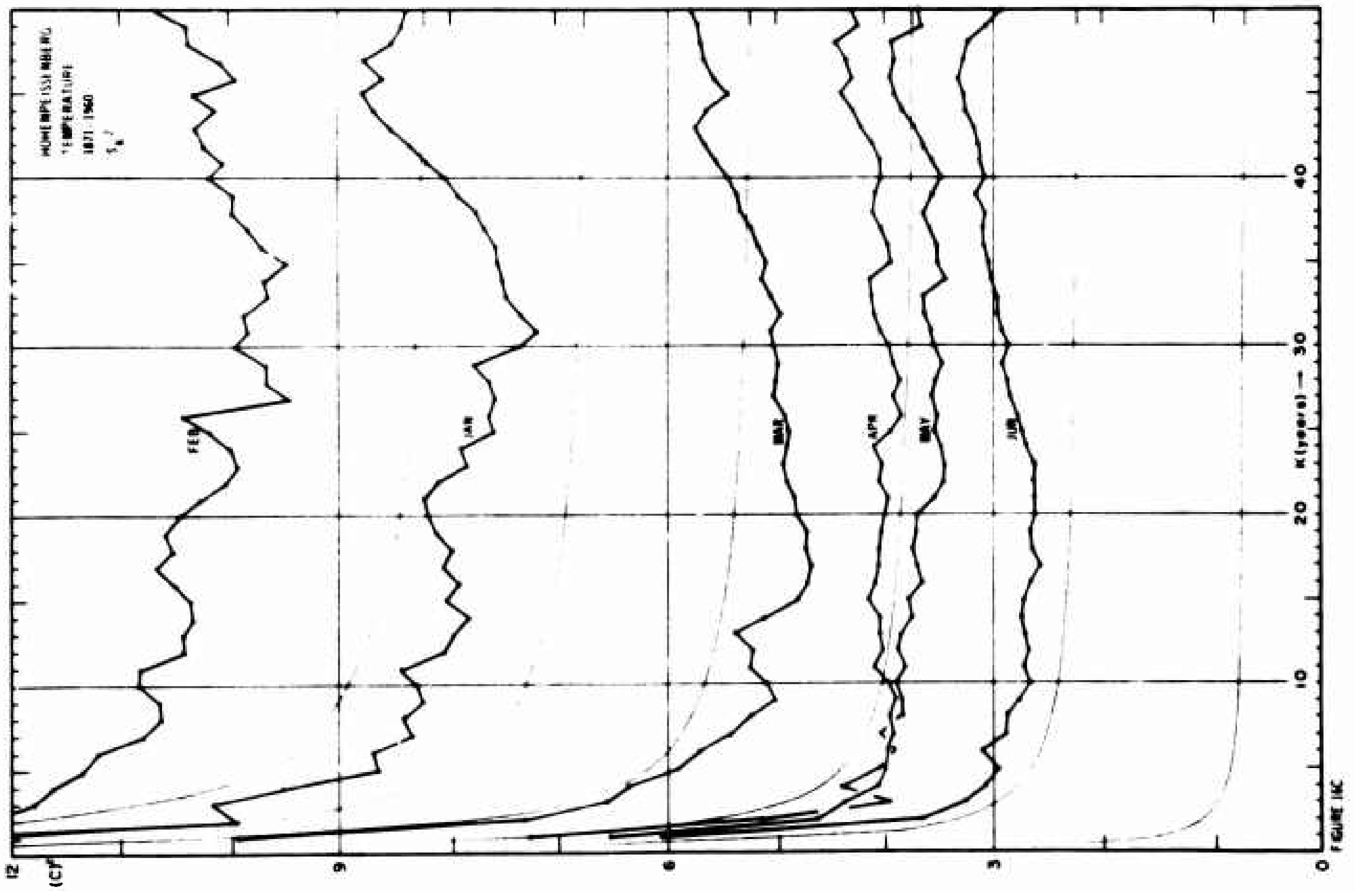


FIGURE 16C

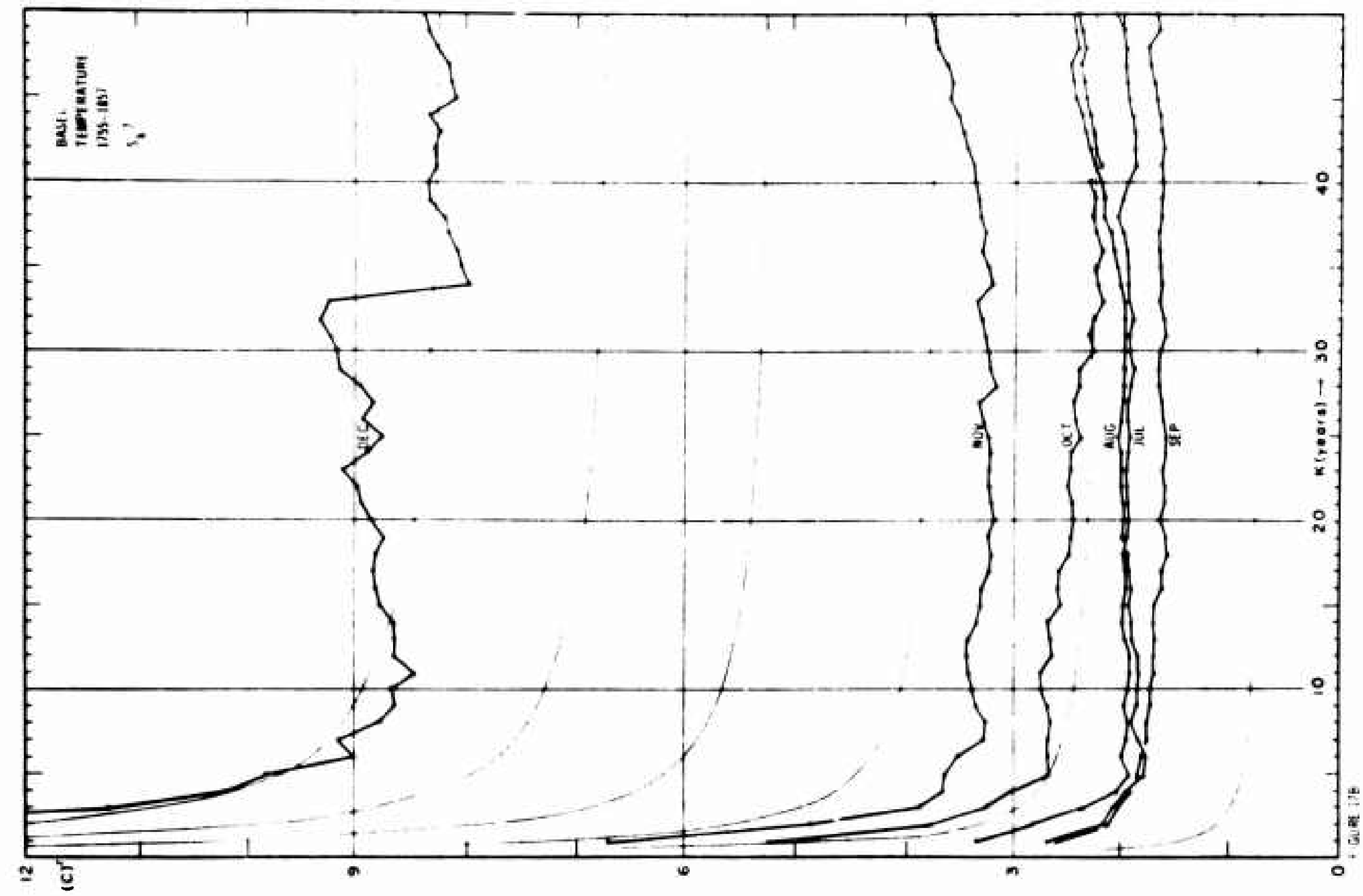


FIGURE 17B

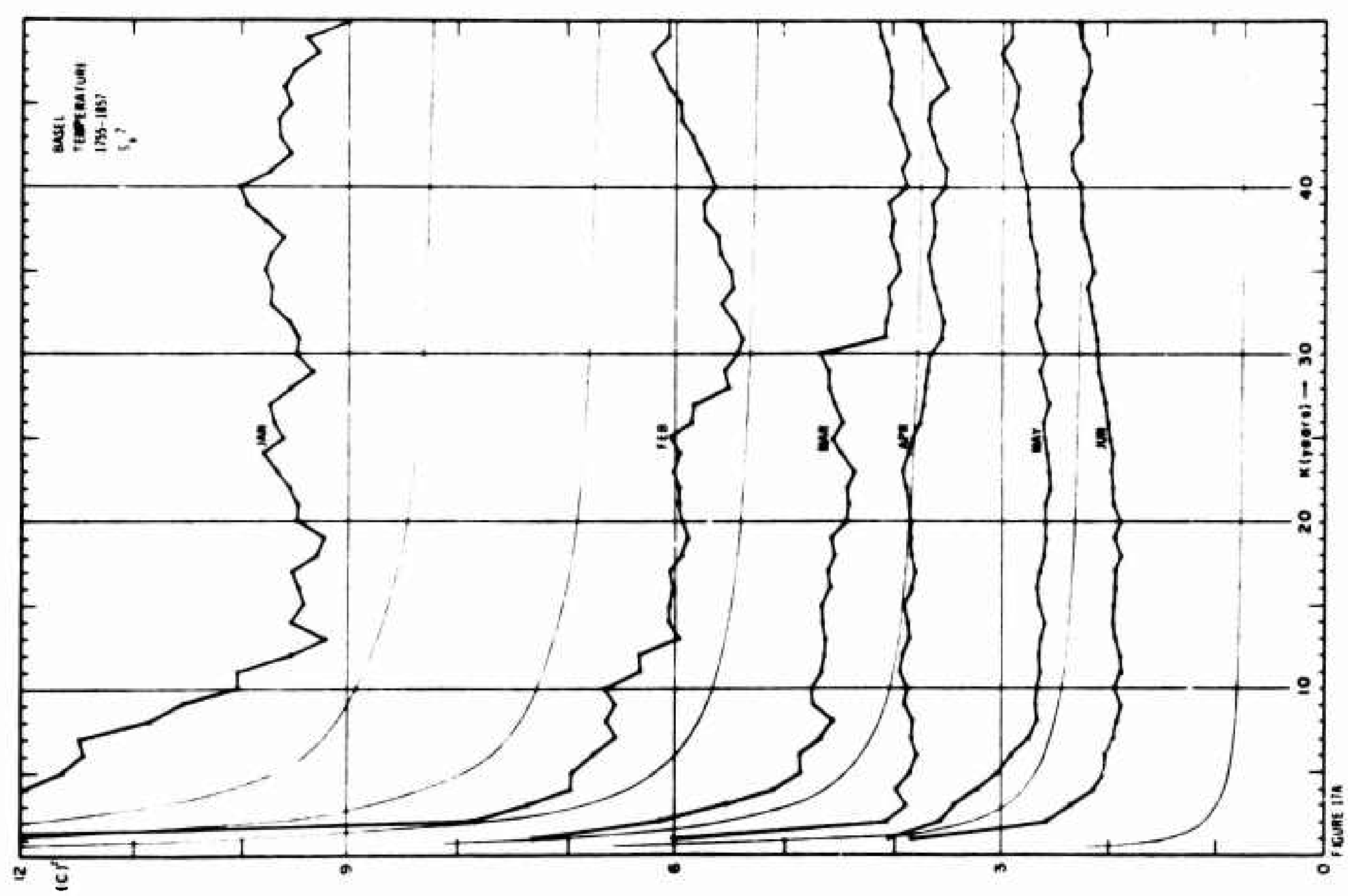
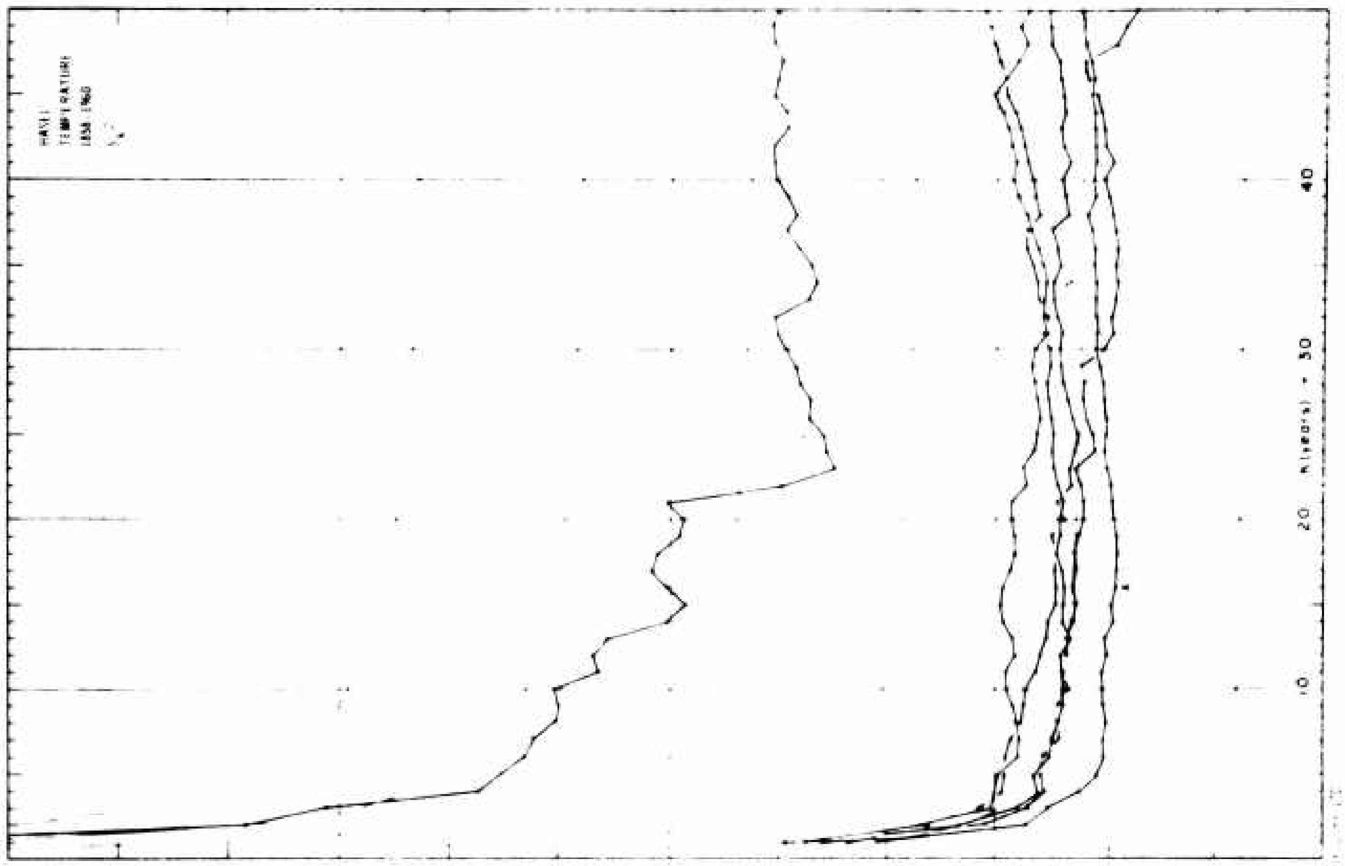
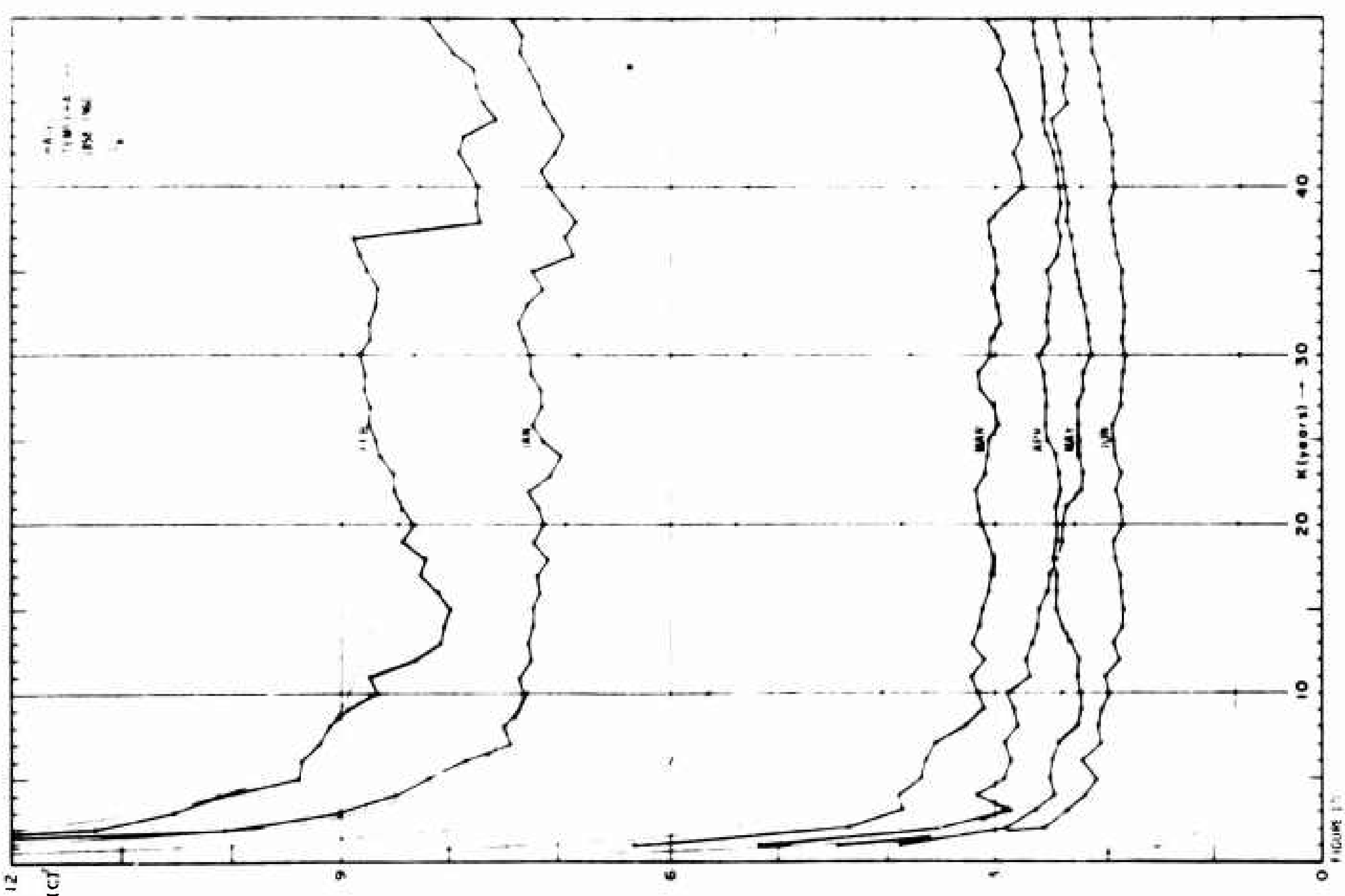
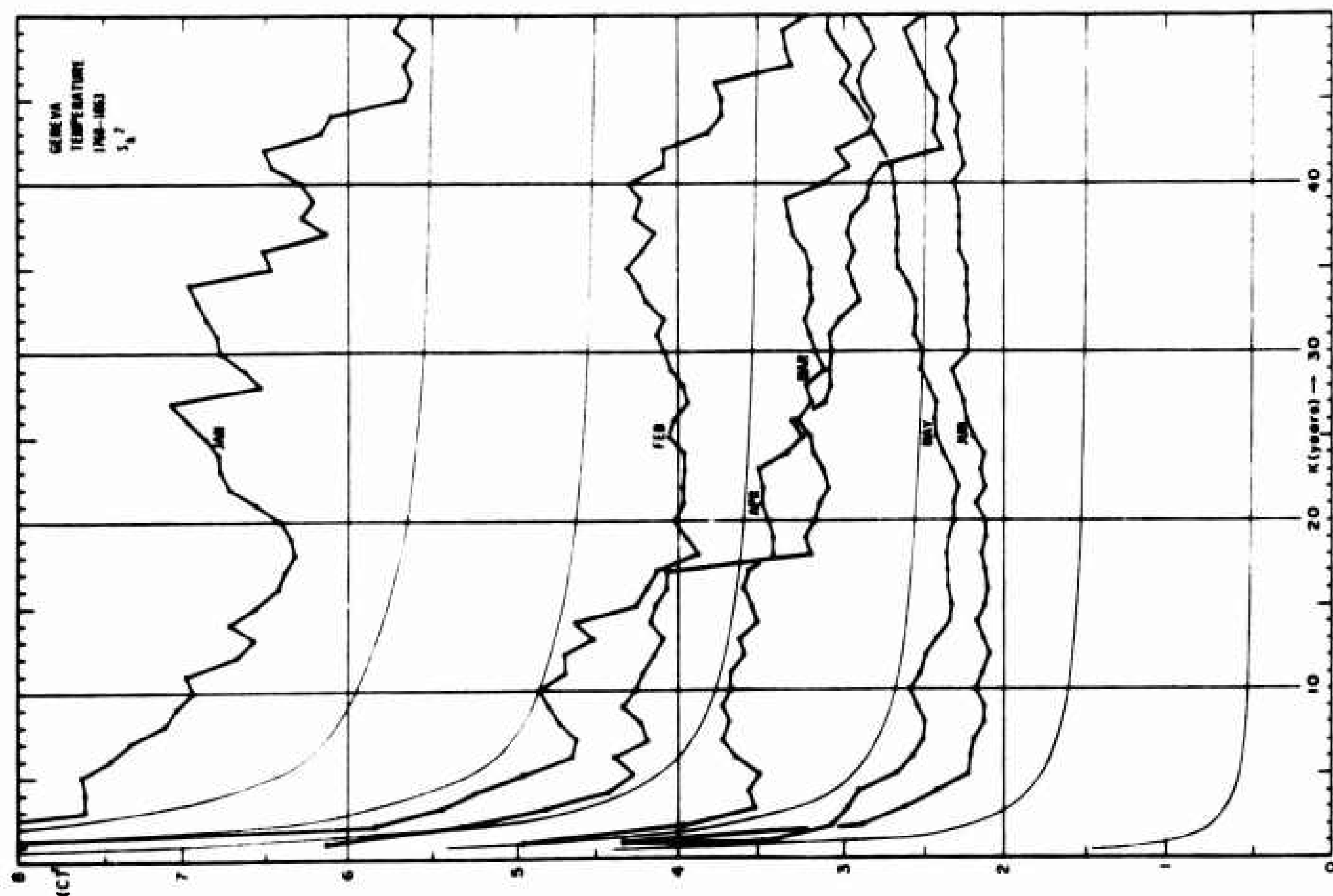
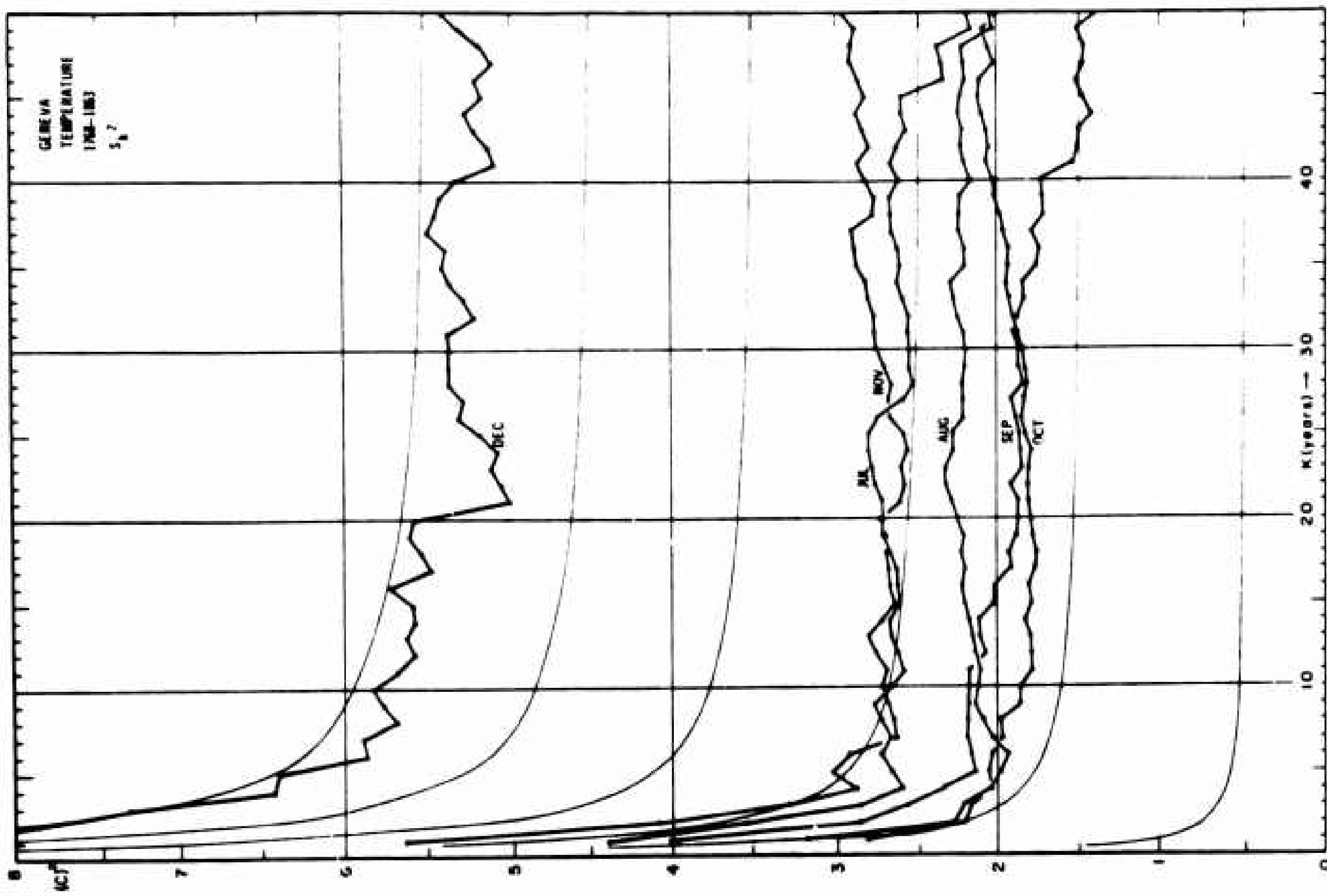


FIGURE 17A






GENEVA
TEMPERATURE
JAN
FEB
APR
MAR
MAY
JUN
K(years) →
(C)²
FIGURE 18A


GENEVA
TEMPERATURE
DEC
JUL
NOV
AUG
SEP
OCT
K(years) →
(C)²
FIGURE 18B

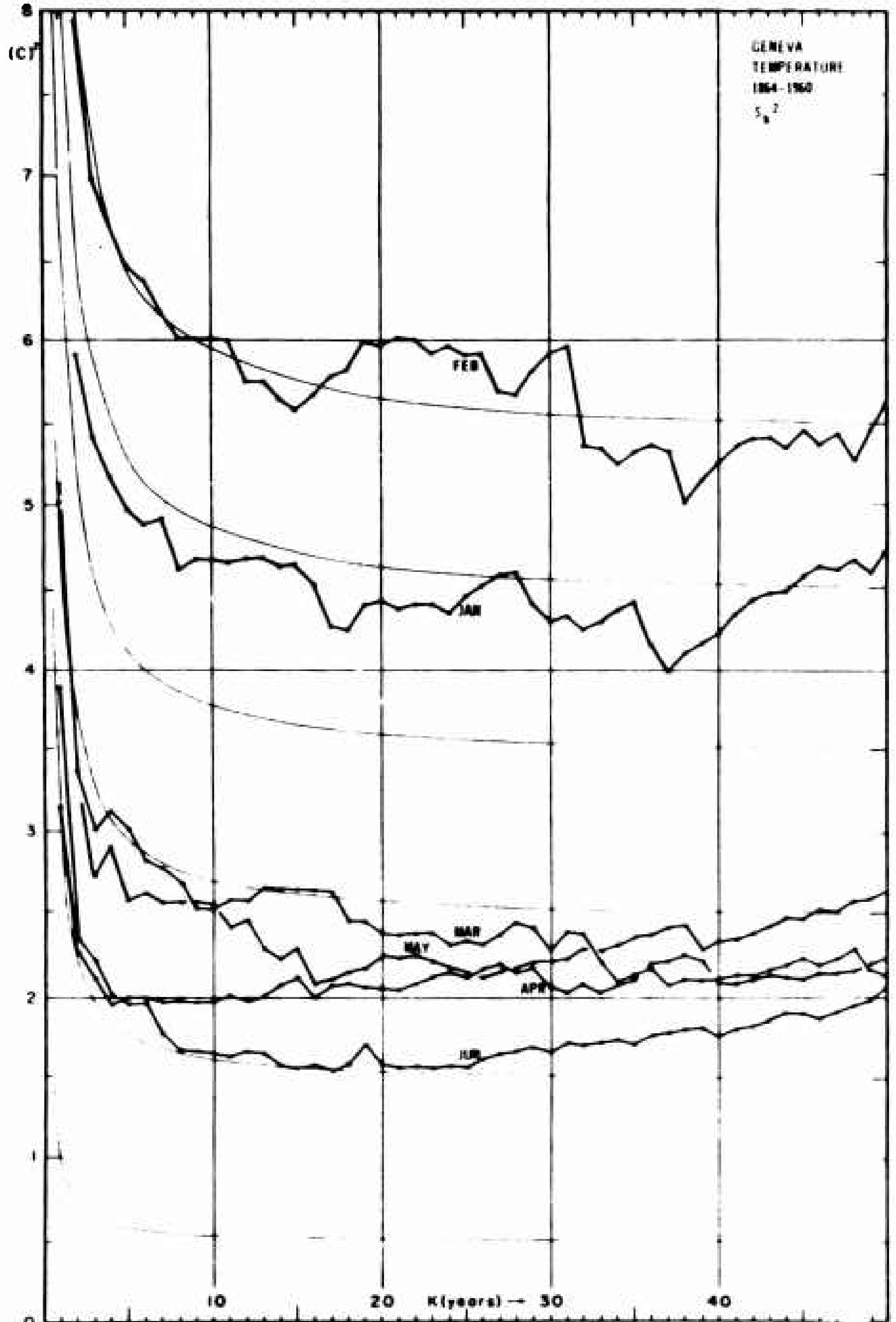


FIGURE 18C

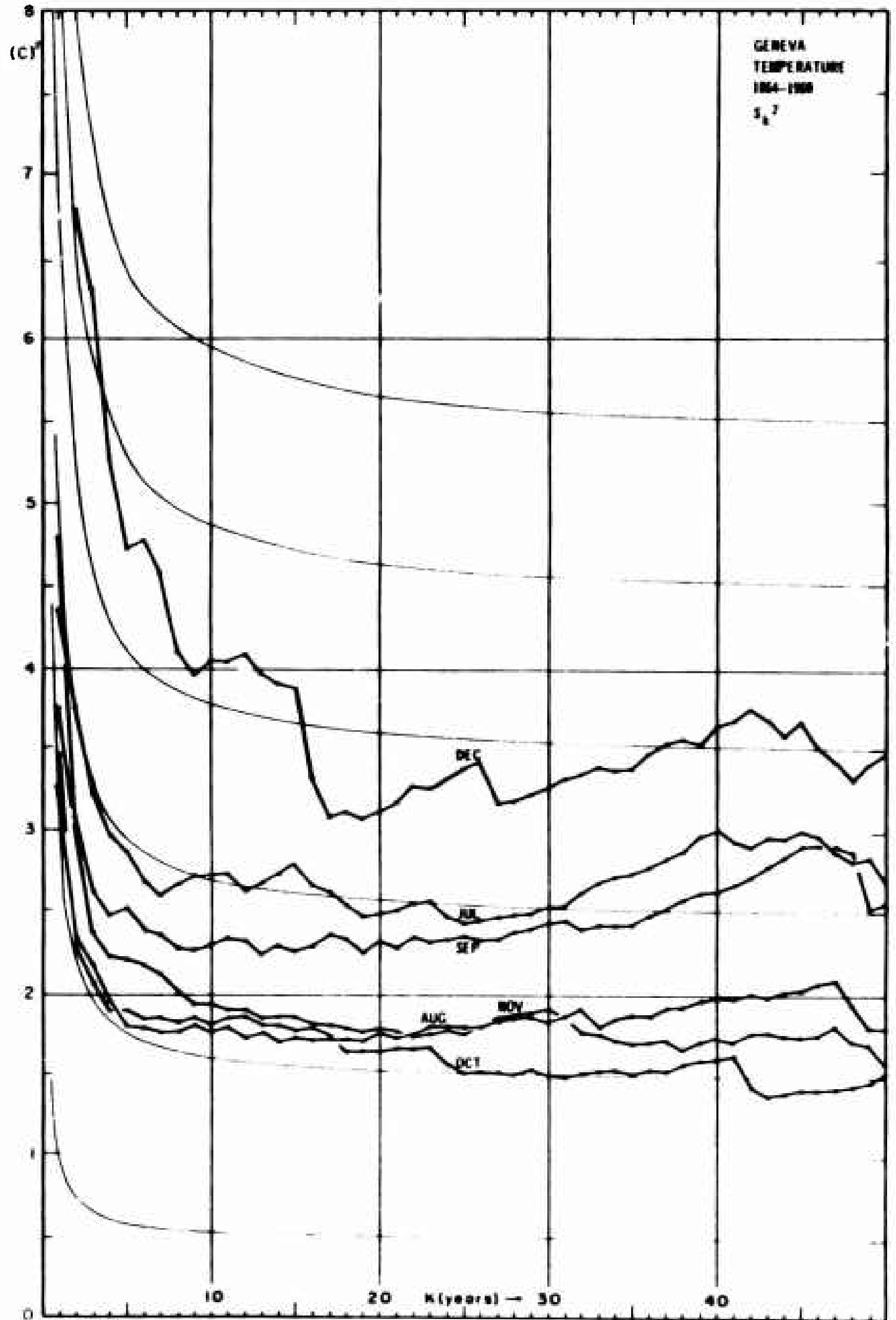


FIGURE 18D

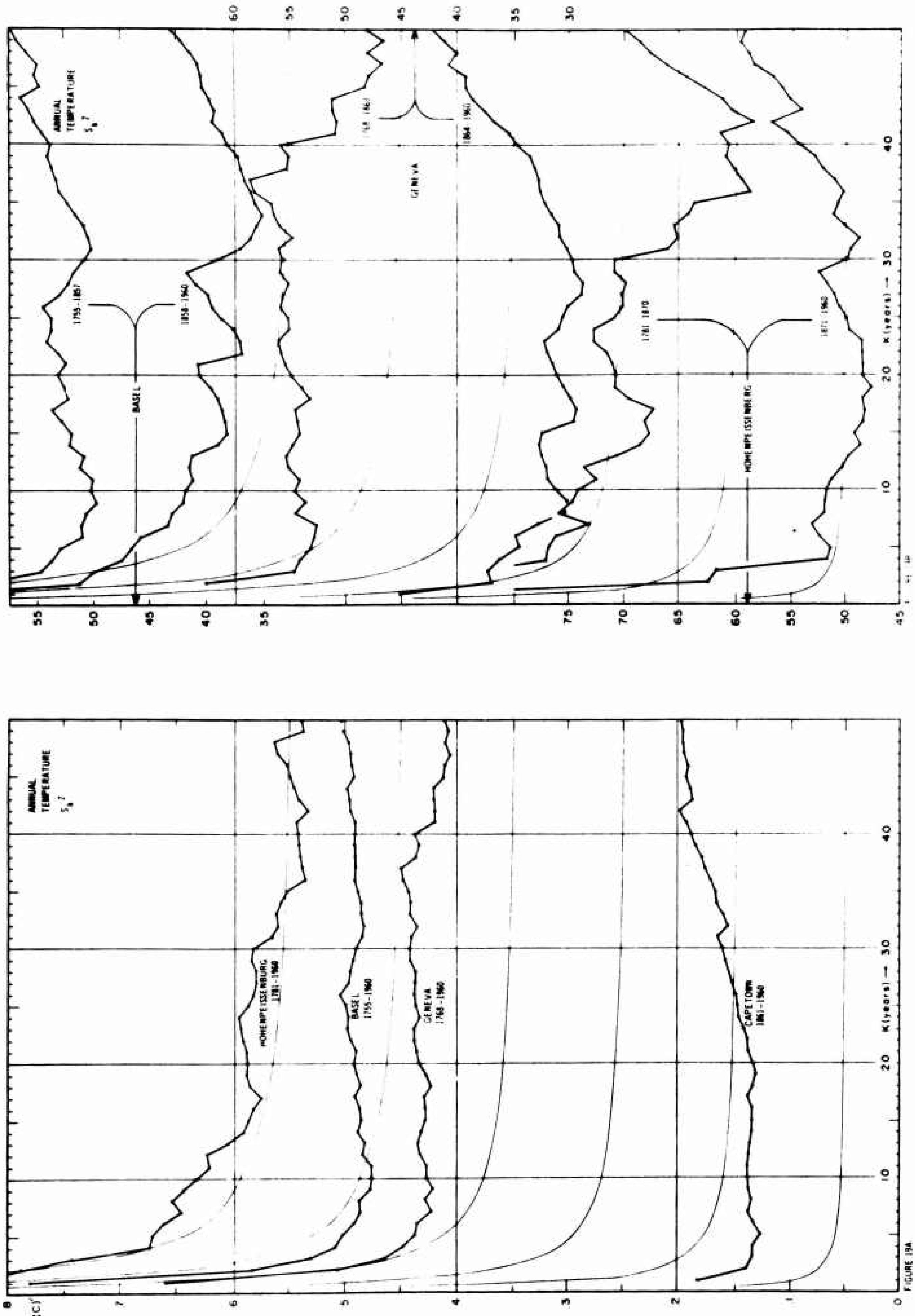
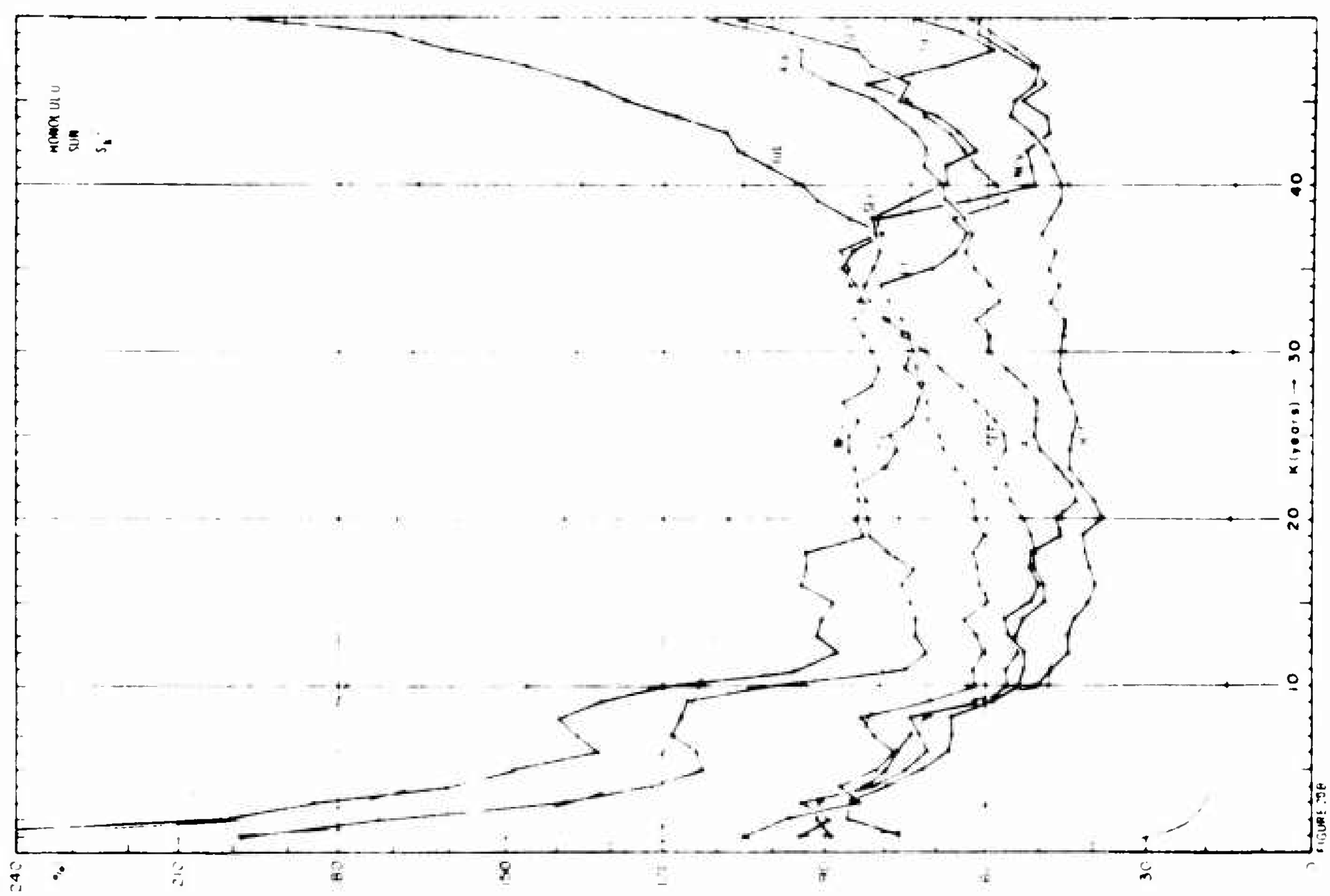
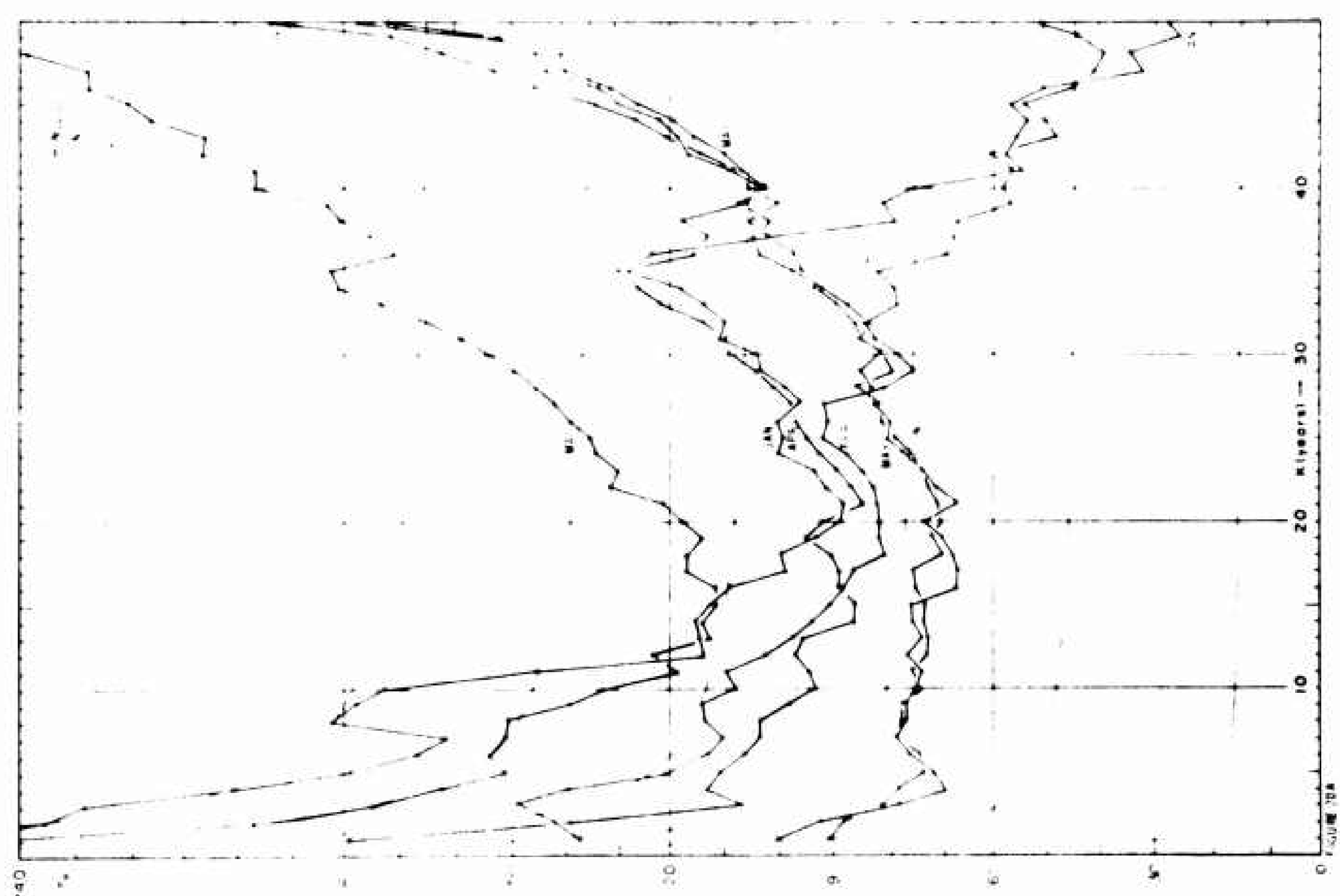

ANNUAL TEMPERATURE
BASEL
1755-1857
1858-1960
GENEVA
1864-1960
HOHENPEISSENBERG
1781-1870
1871-1960
K (years) →
ANNUAL TEMPERATURE
HOHENPEISSENBERG 1781-1960
BASEL 1755-1960
GENEVA 1768-1960
CAPETOWN 1861-1960
K (years) →

FIGURE 19A


HONOLULU
SUN
K(years) →
FIGURE 7B
10
20
30
40


K(years) →
FIGURE 7A
10
20
30
40

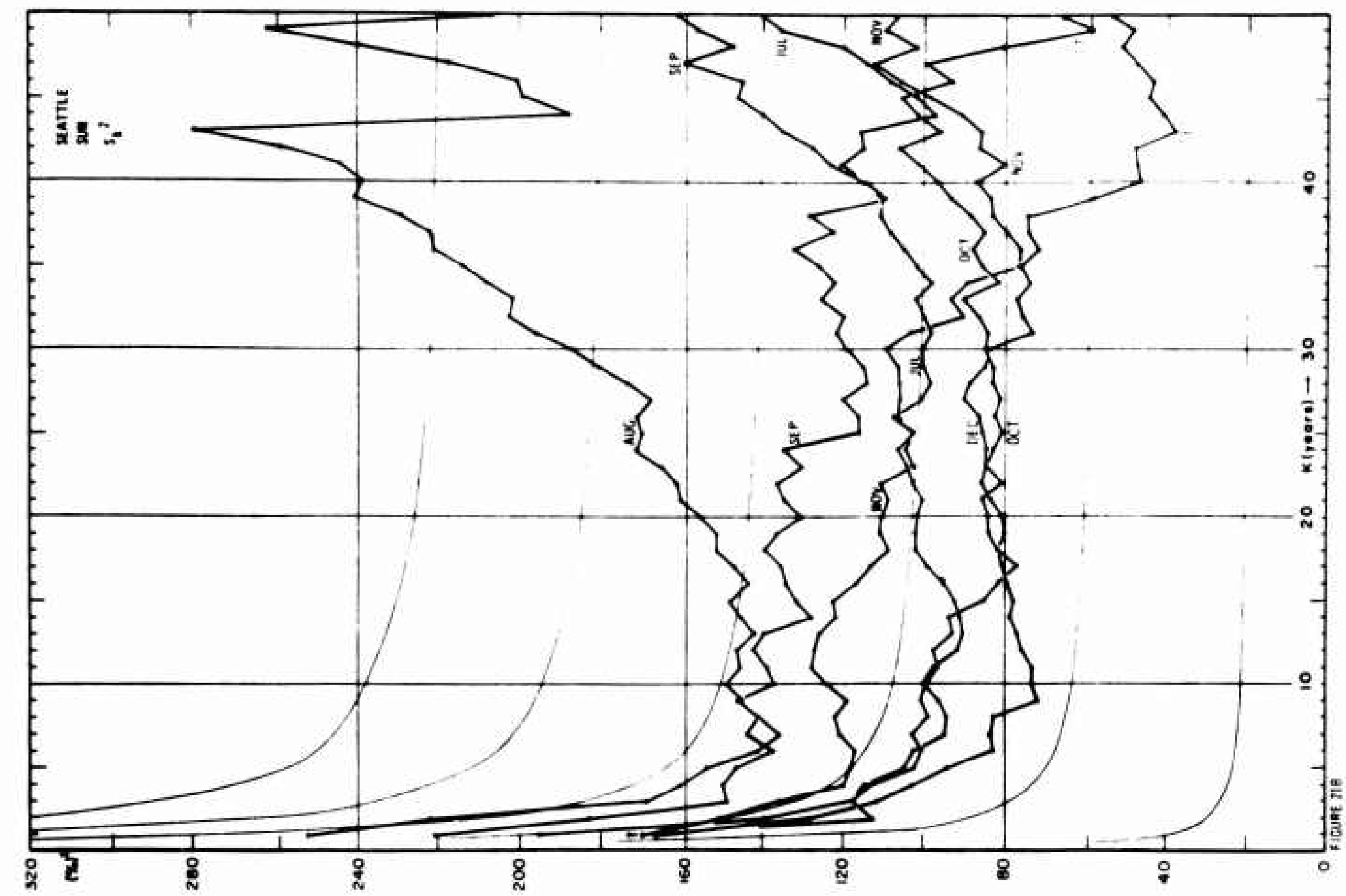


FIGURE 21B

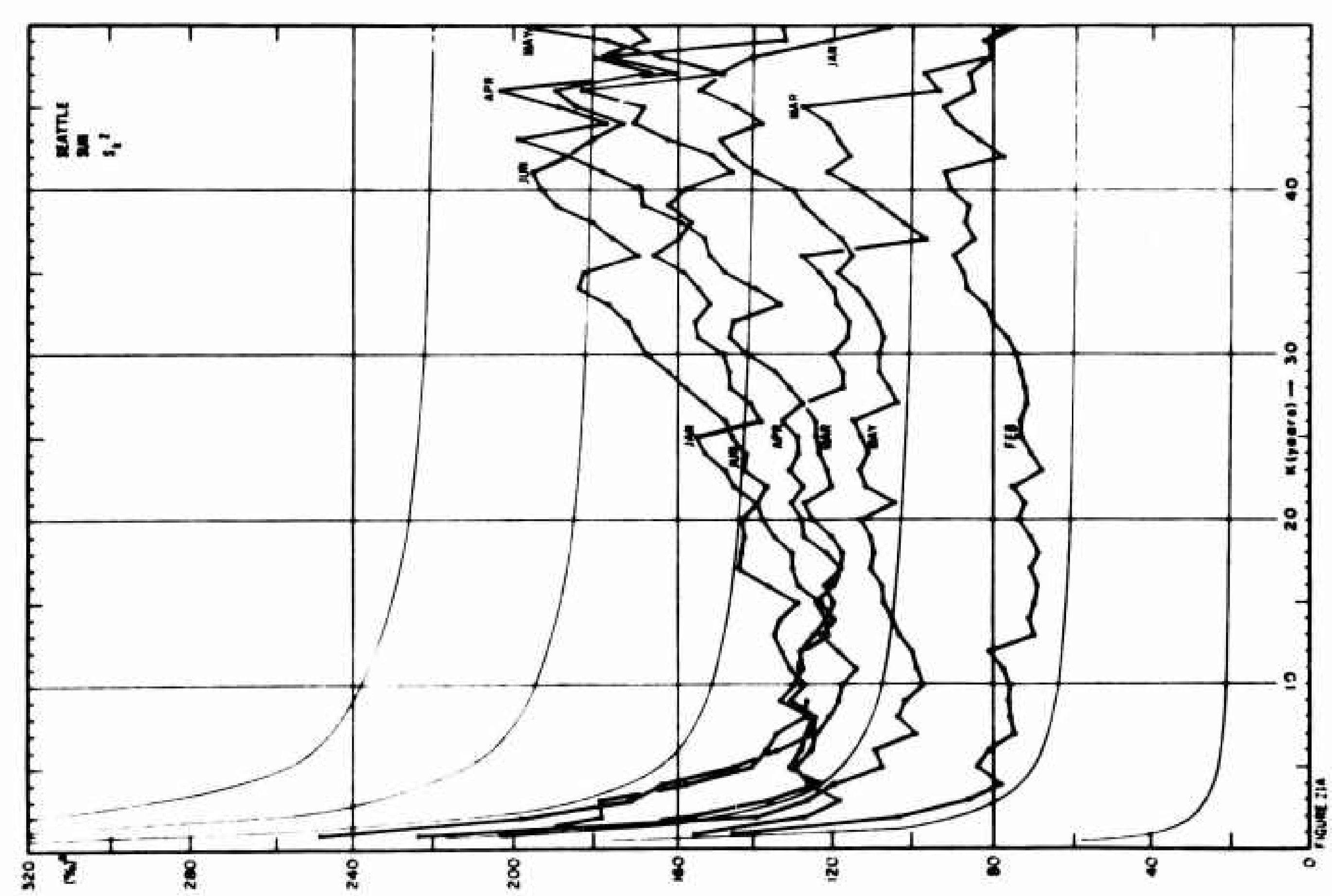
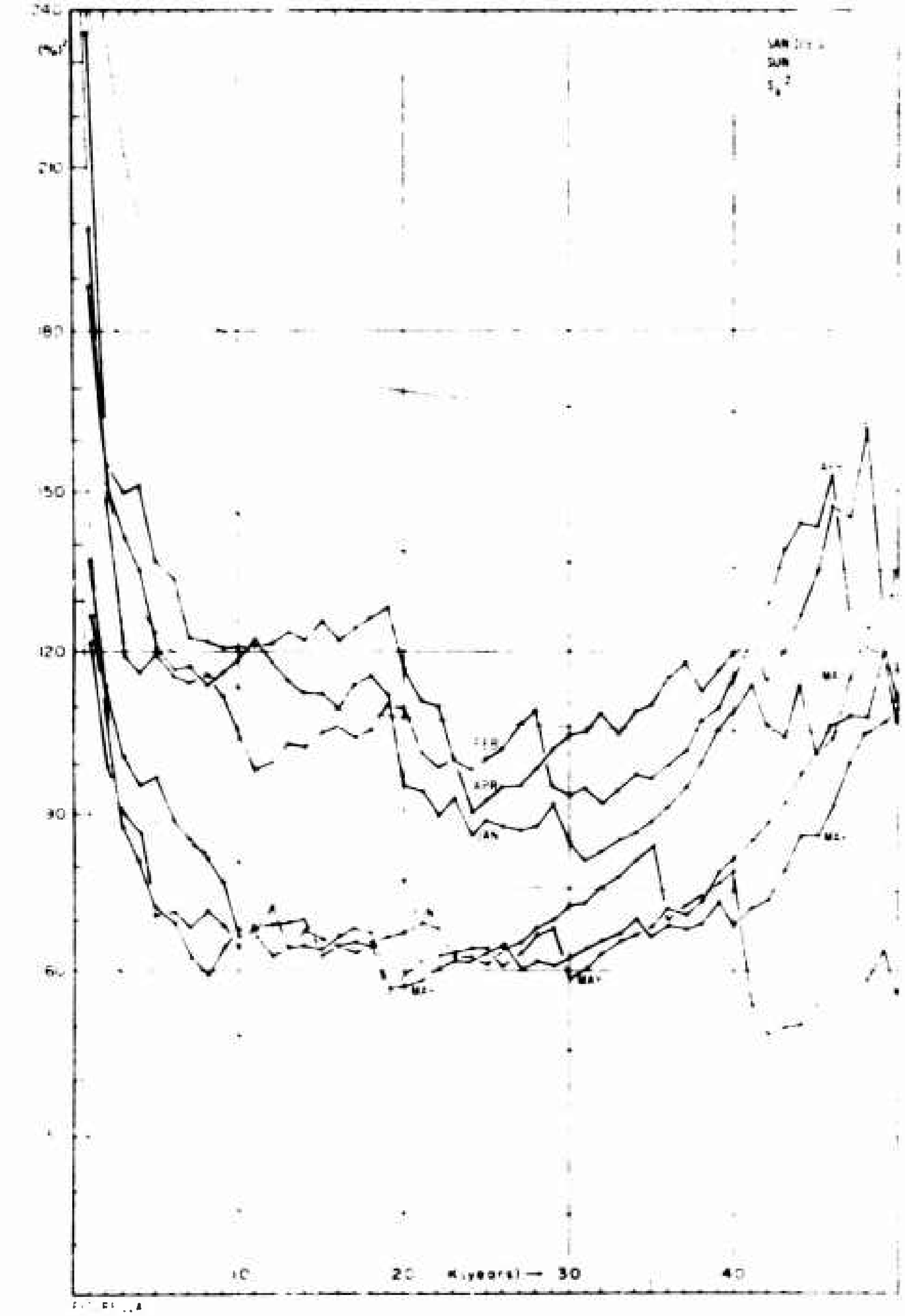
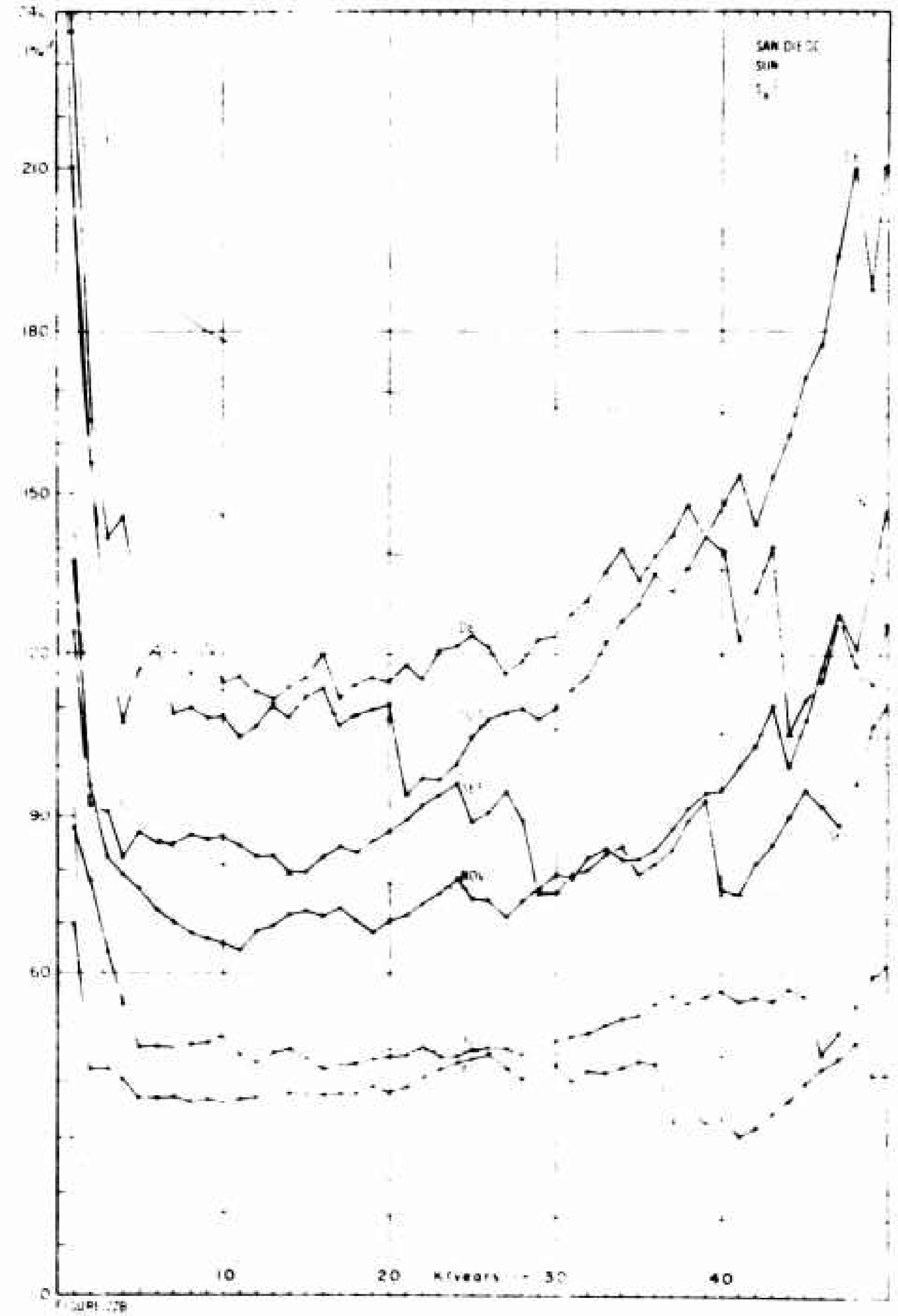
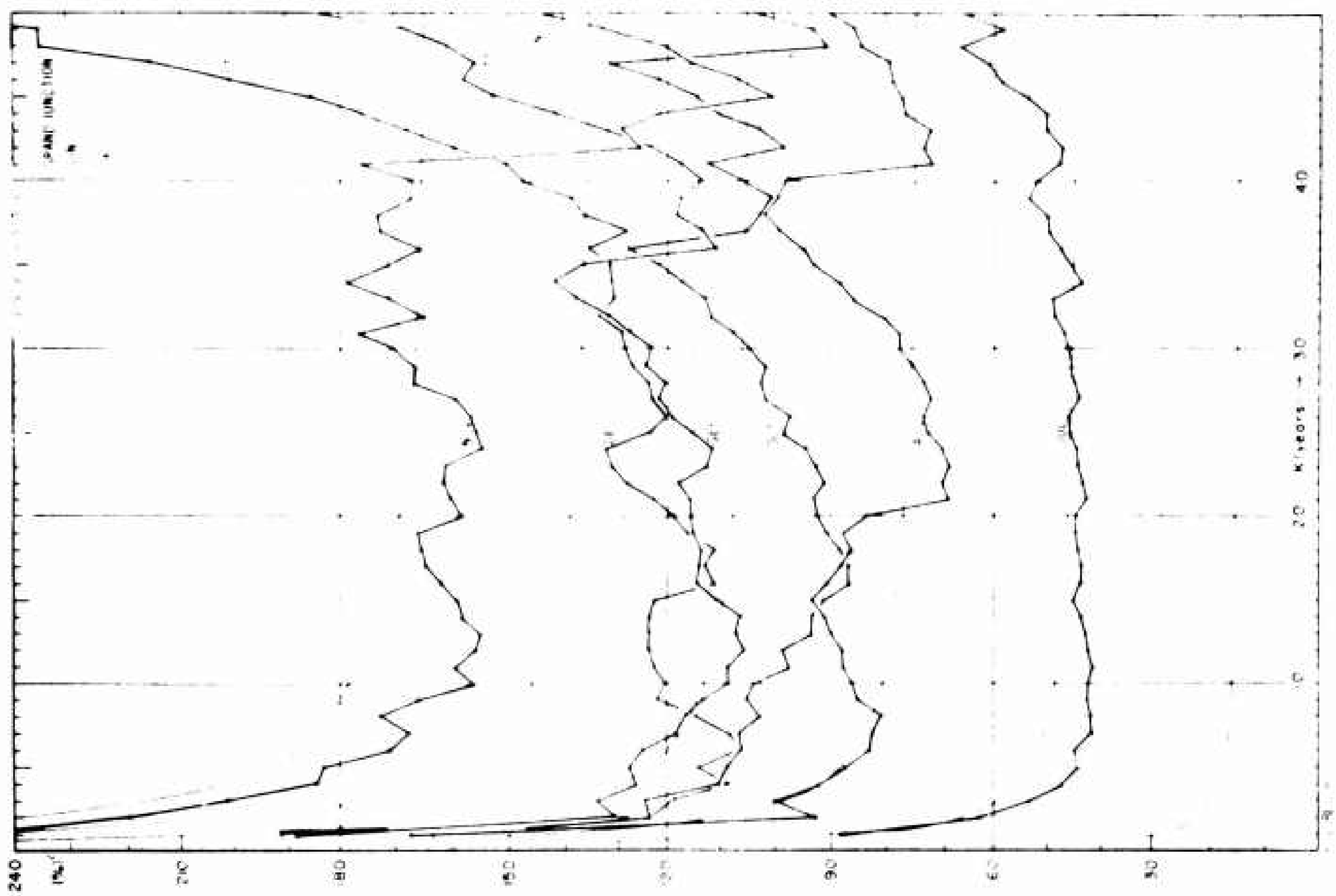


FIGURE 21A


SUN
210
180
150
120
90
60
10
20
K(years) — 30
40
FEB
APR
JAN


SAN DIEGO
SUN
210
180
150
90
60
0
10
20
40


GRAND JUNCTION
K(years) → 30
240
210
180
150
120
90
60
30
10
20
30
40

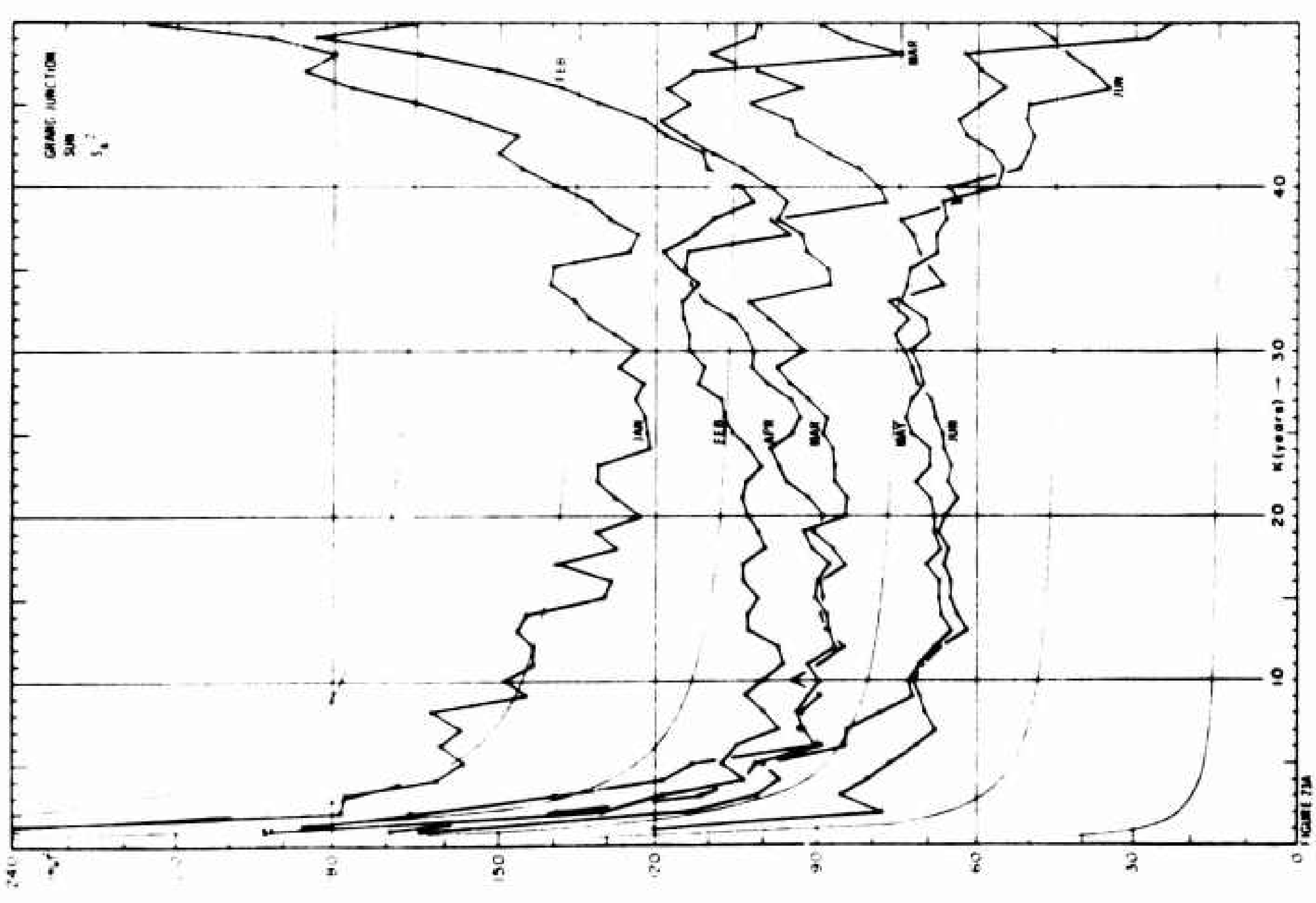
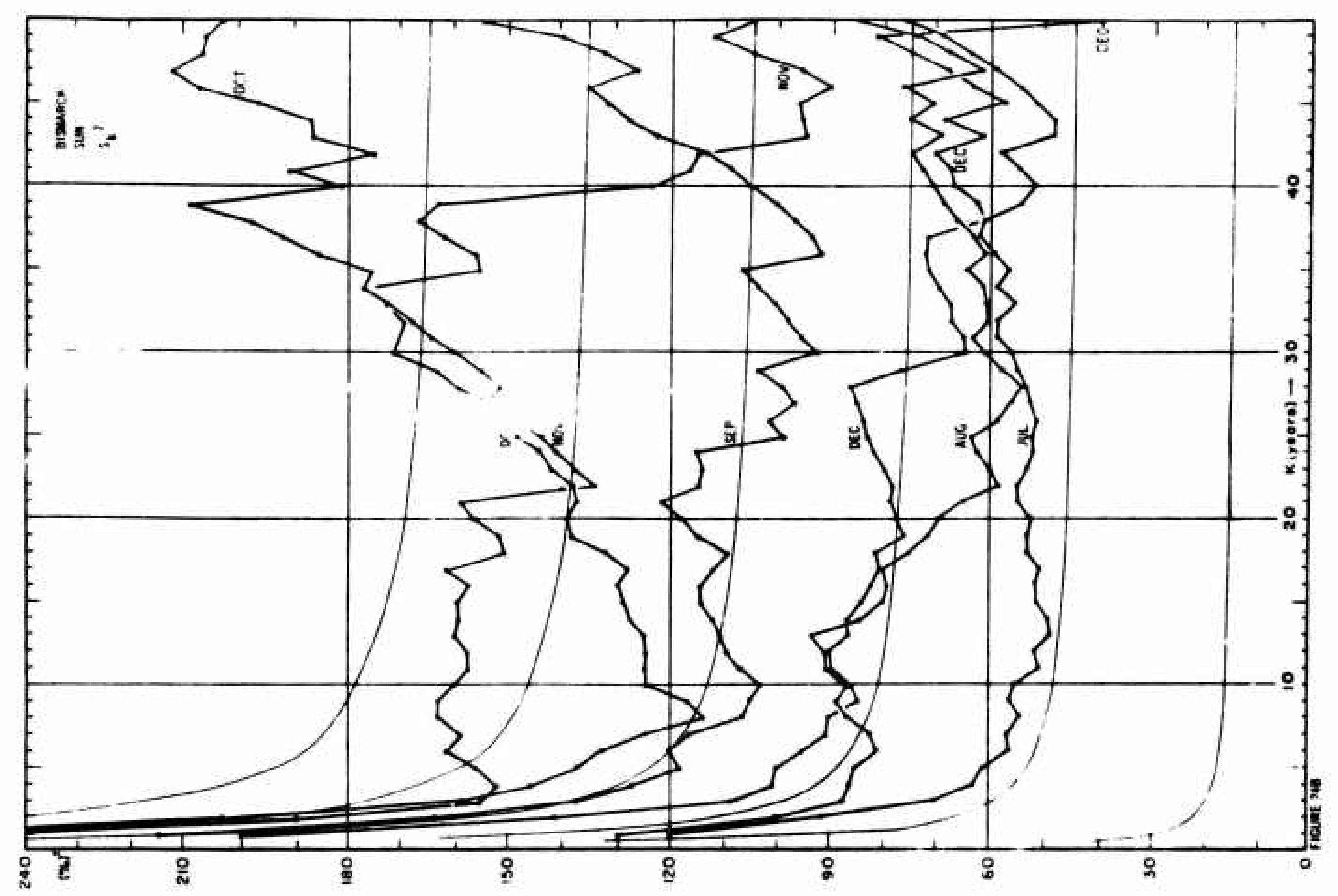
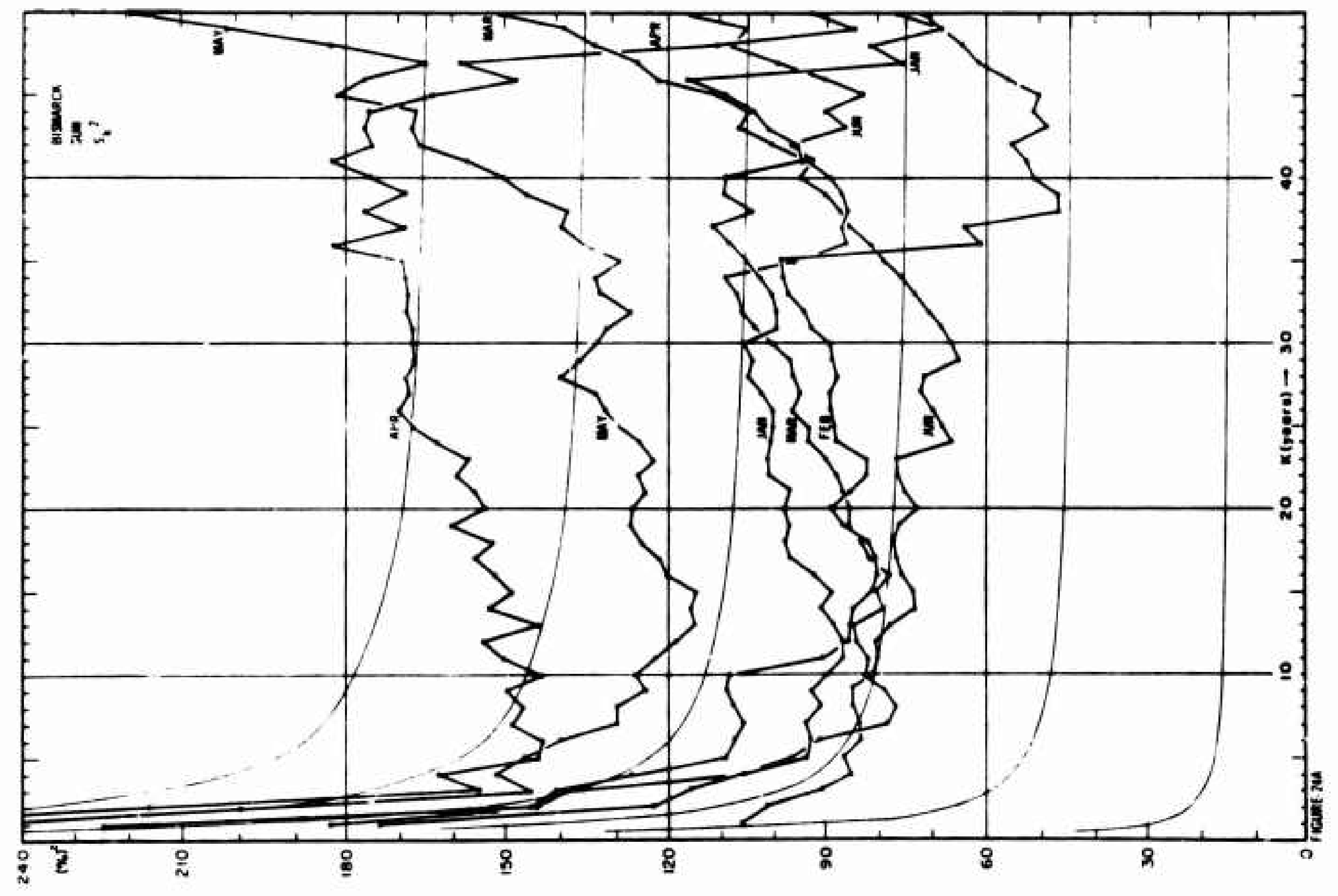

GRAND JUNCTION
SUN
JAN
FEB
APR
MAR
MAY
JUN
K(years) → 30
240
180
150
120
90
60
30
0
10
20
30
40

FIGURE 7IA


BISMARCK
SUN
OCT
NOV
SEP
DEC
AUG
JUL
K (years)
240
210
180
150
120
90
60
30
0
10
20
30
40


BISMARCK
SUN
MAY
MAR
APR
JAN
JUN
FEB
AUG
K (years)
240
210
180
150
120
90
60
30
0
10
20
30
40

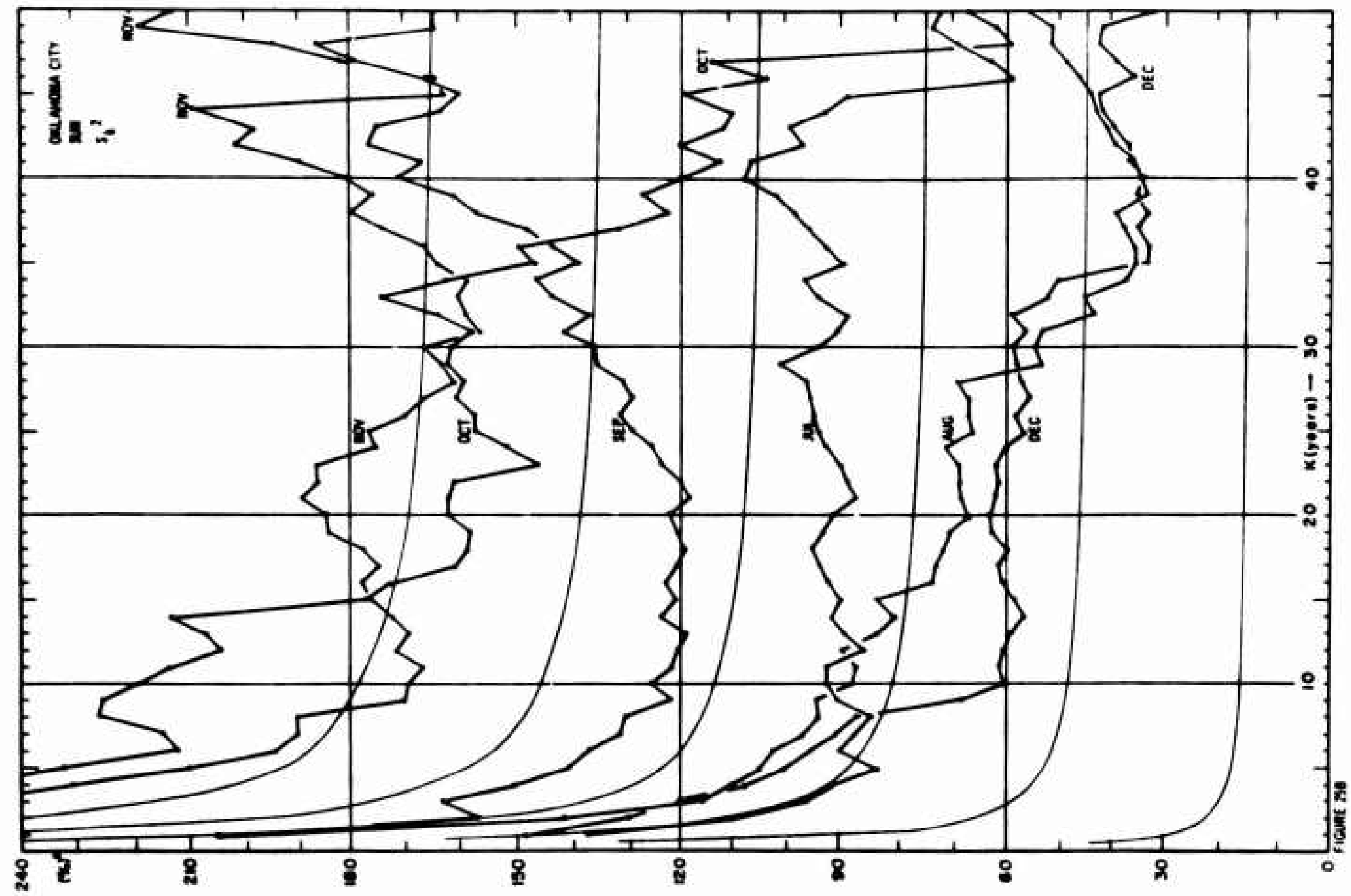


FIGURE 25B

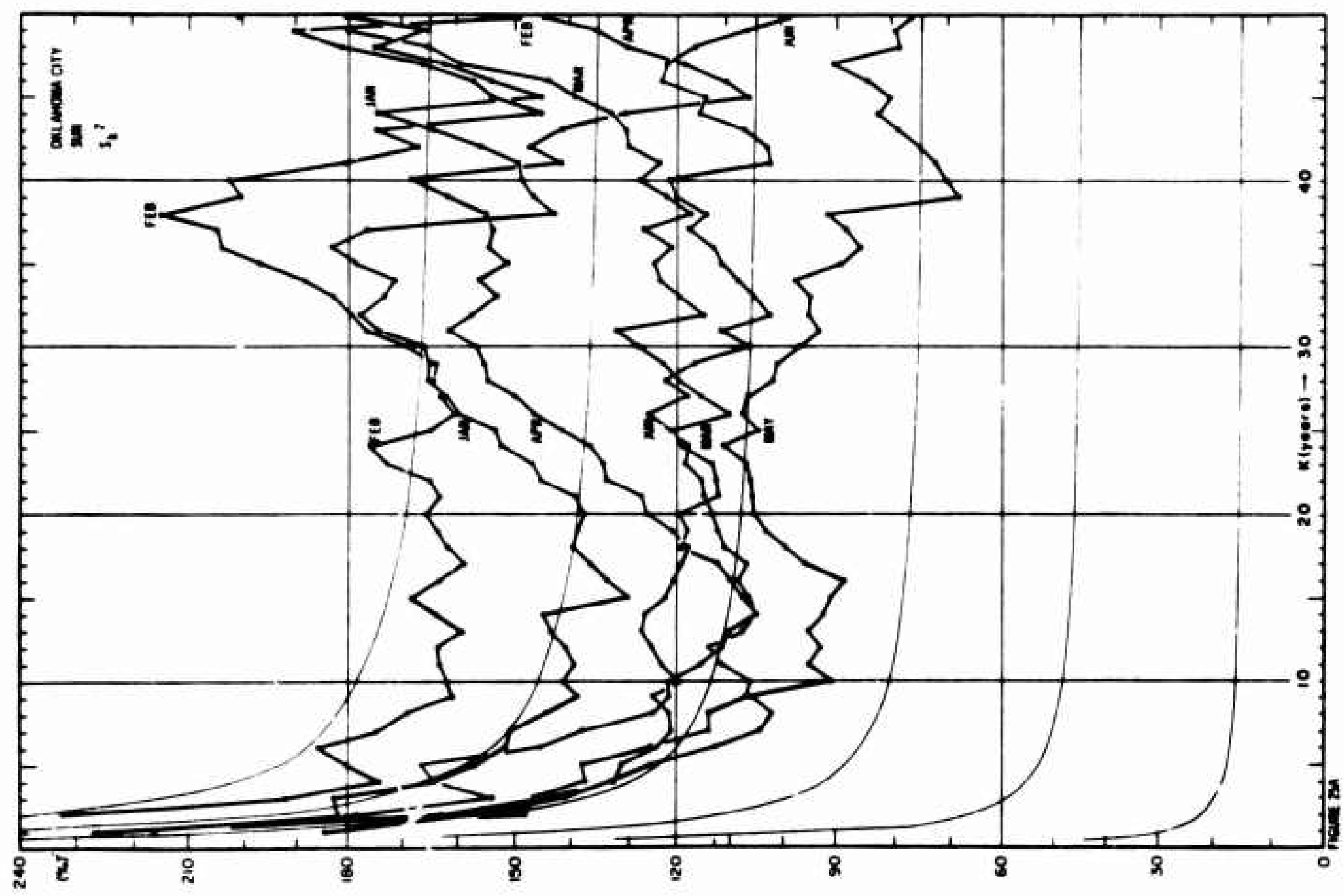


FIGURE 25A

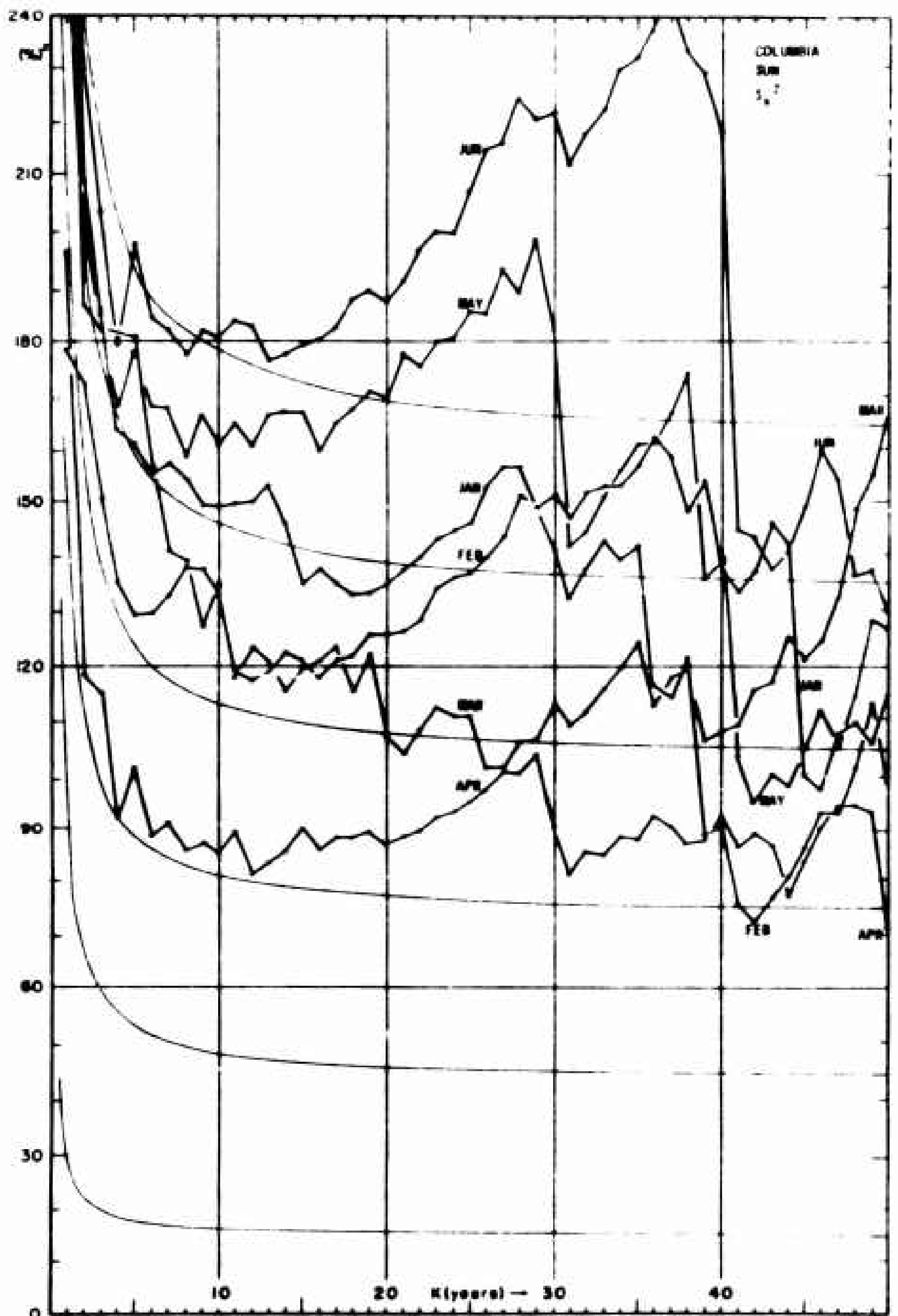


FIGURE 26A

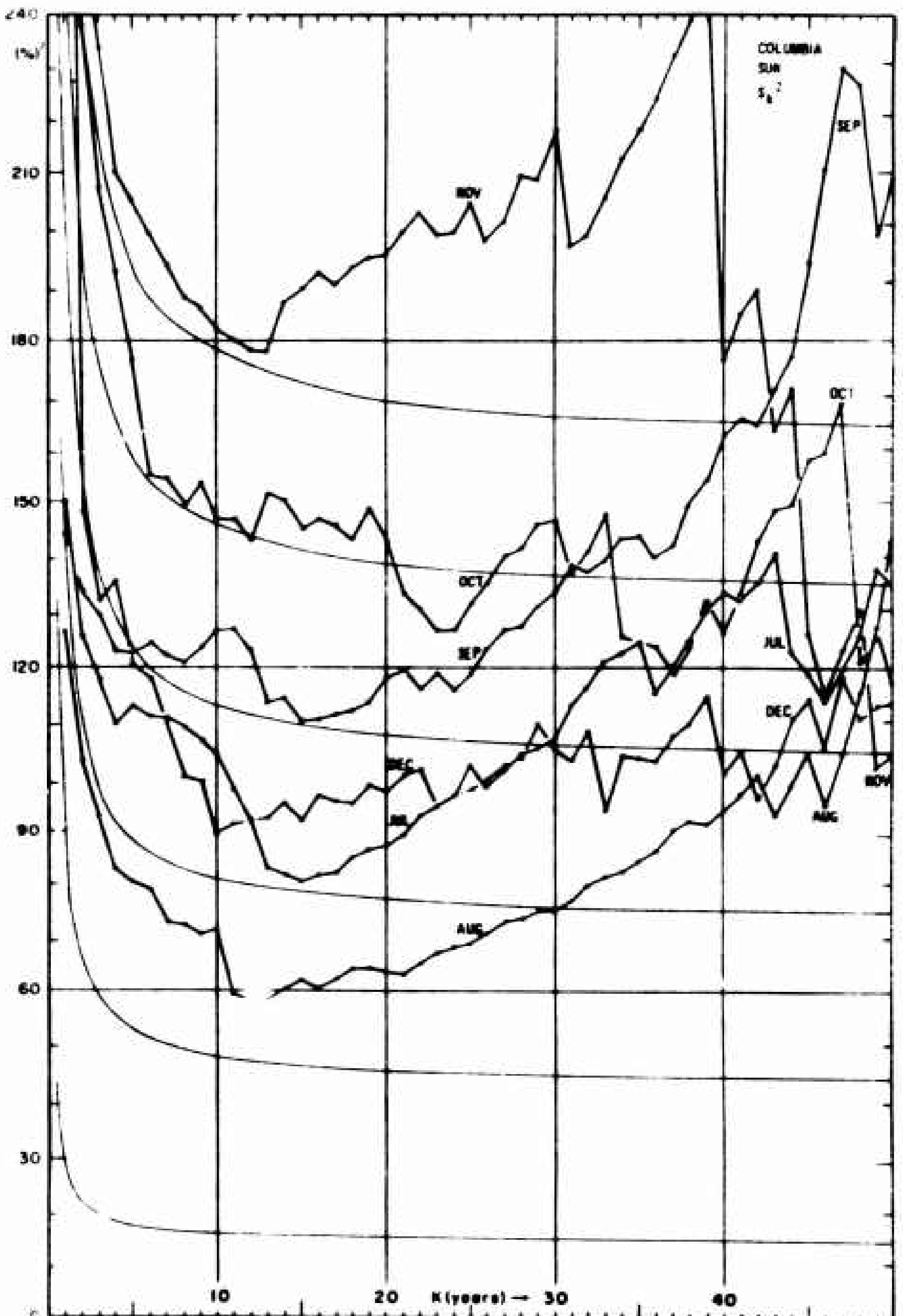


FIGURE 26B

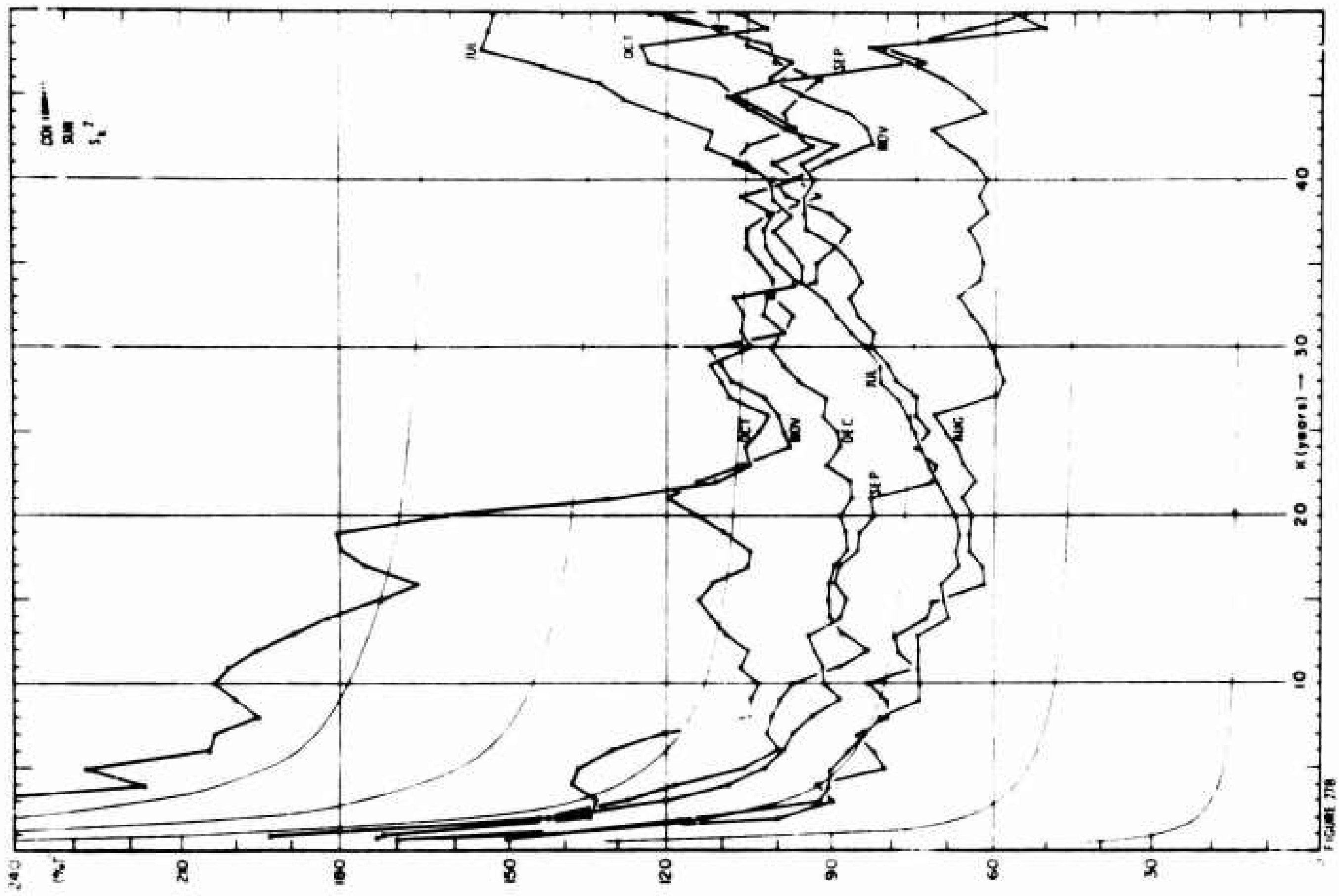


FIGURE 27B
SUN
K(years) →
0
10
20
30
40
30
60
90
120
150
180
210
240
JUL
OCT
SEP
NOV
DEC
AUG

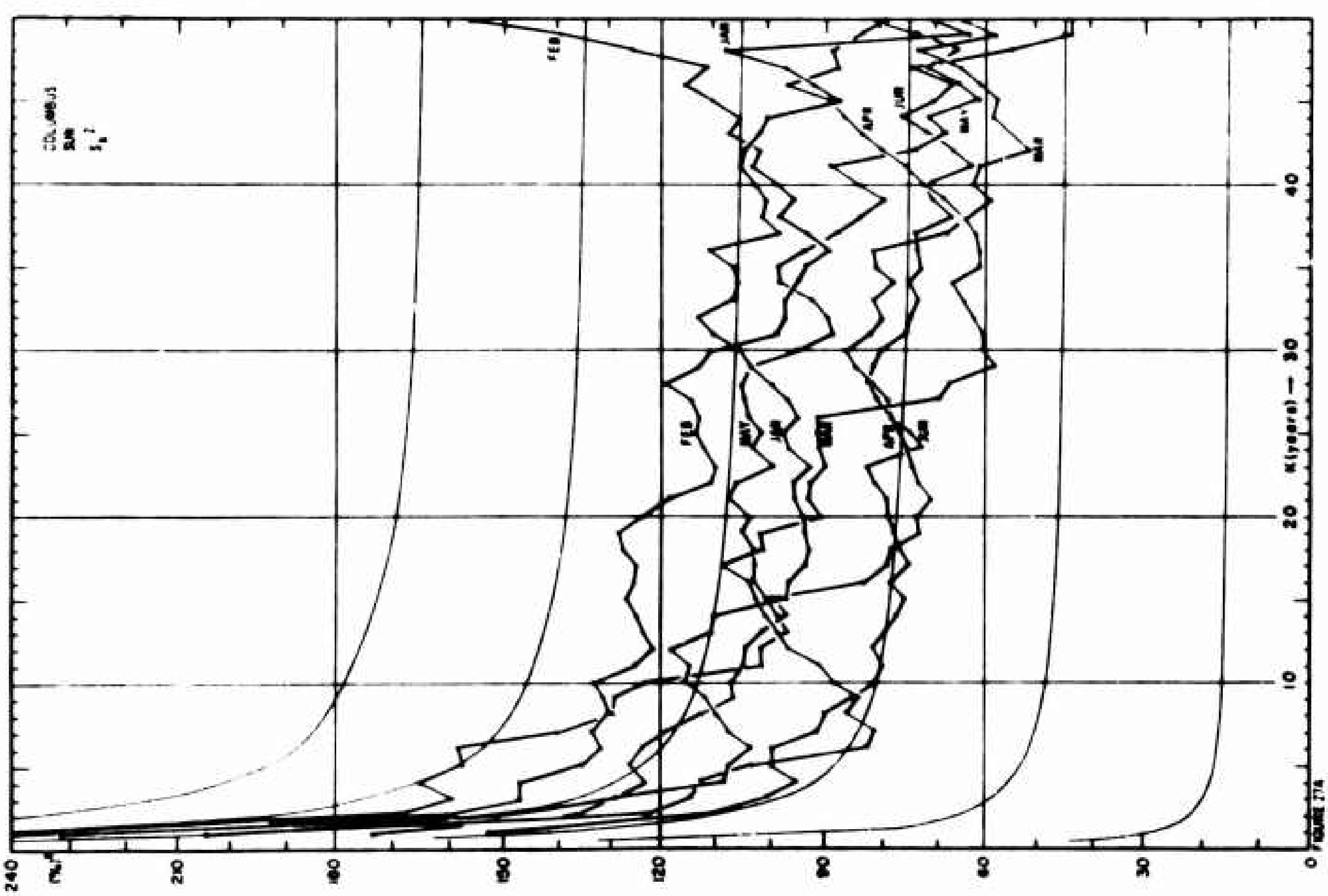


FIGURE 27A
COLUMBUS
SUN
K(years) →
0
10
20
30
40
30
60
90
120
150
180
210
240
FEB
JAN
APR
JUN
MAY
MAR

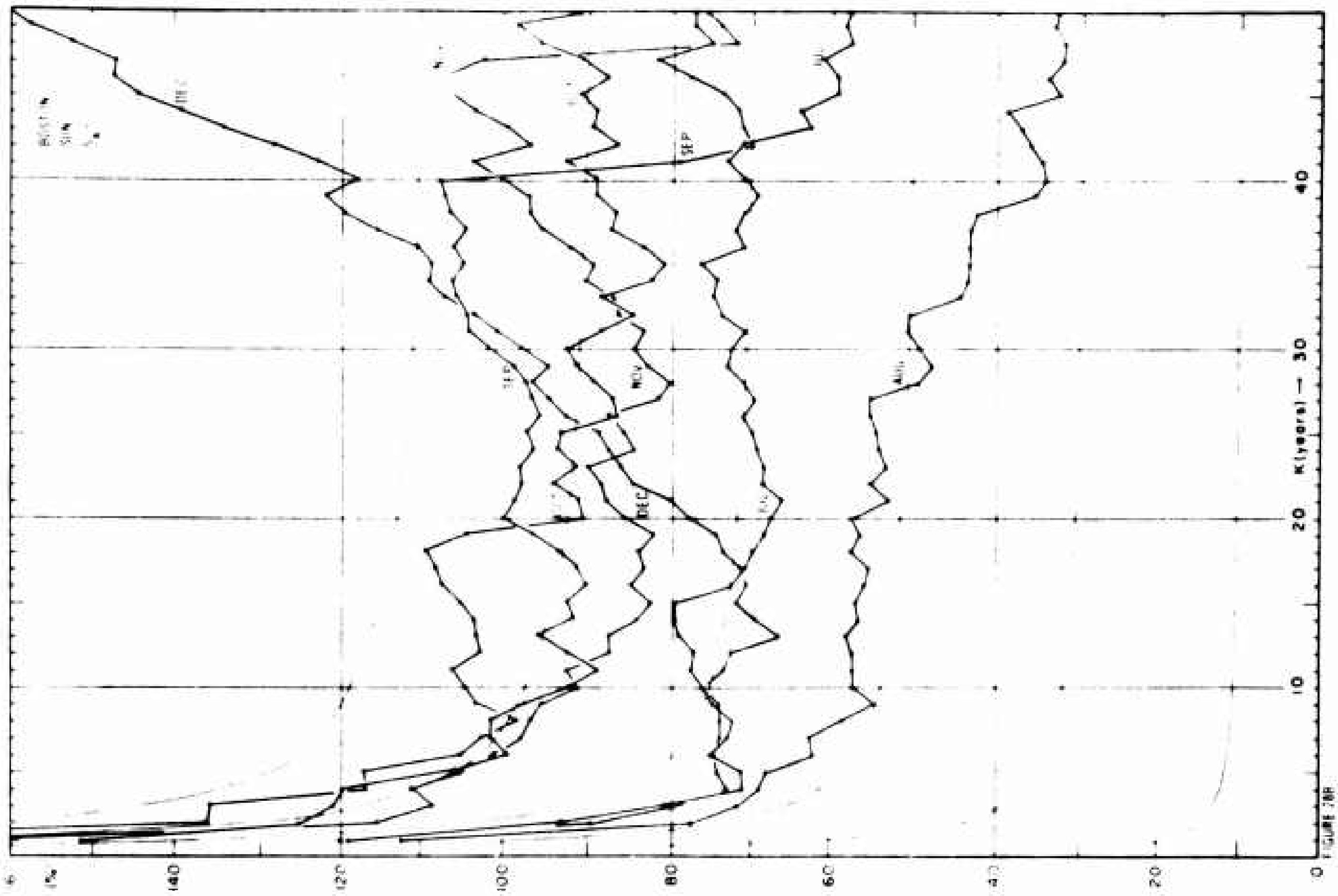


FIGURE 28B

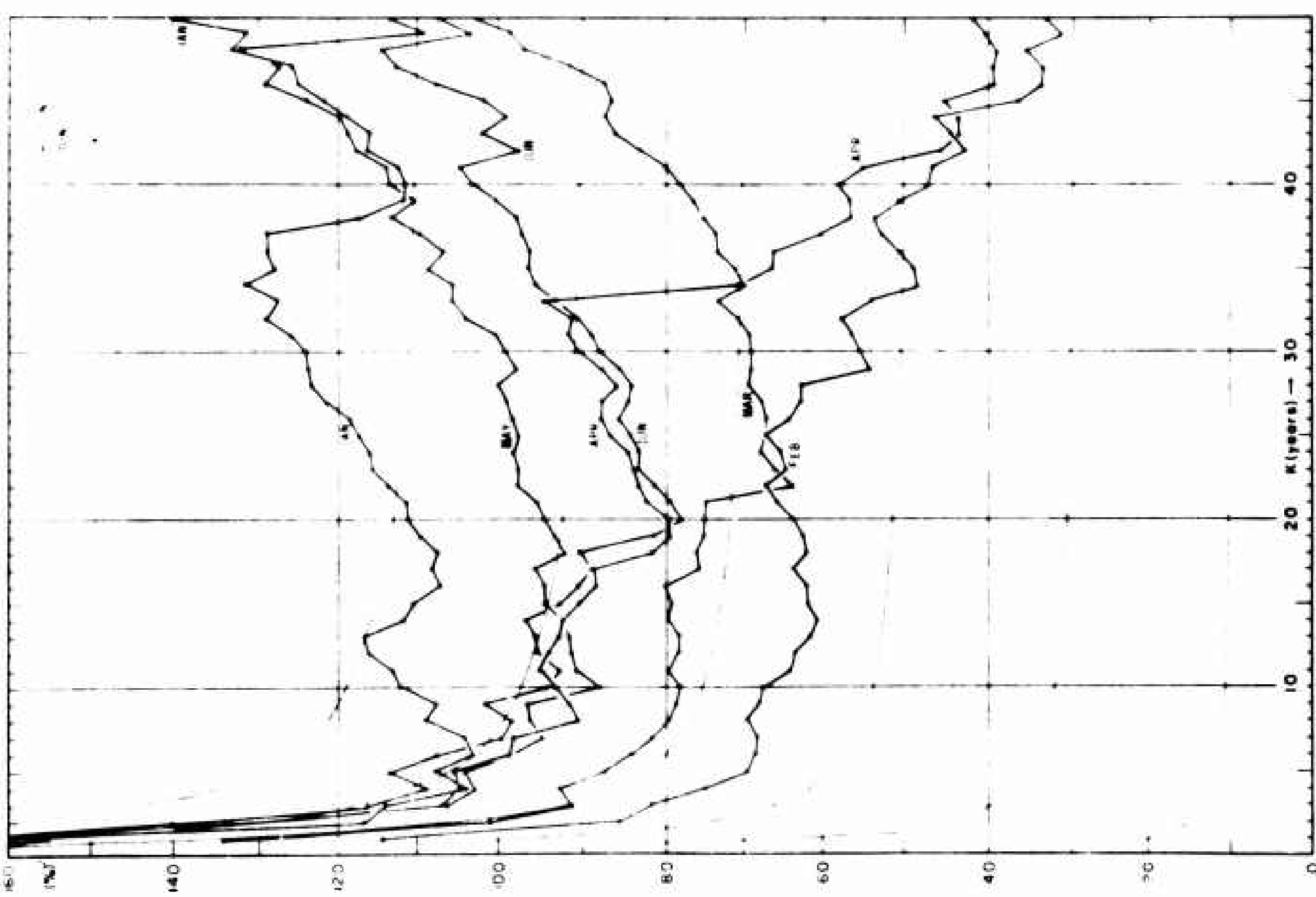


FIGURE 28A

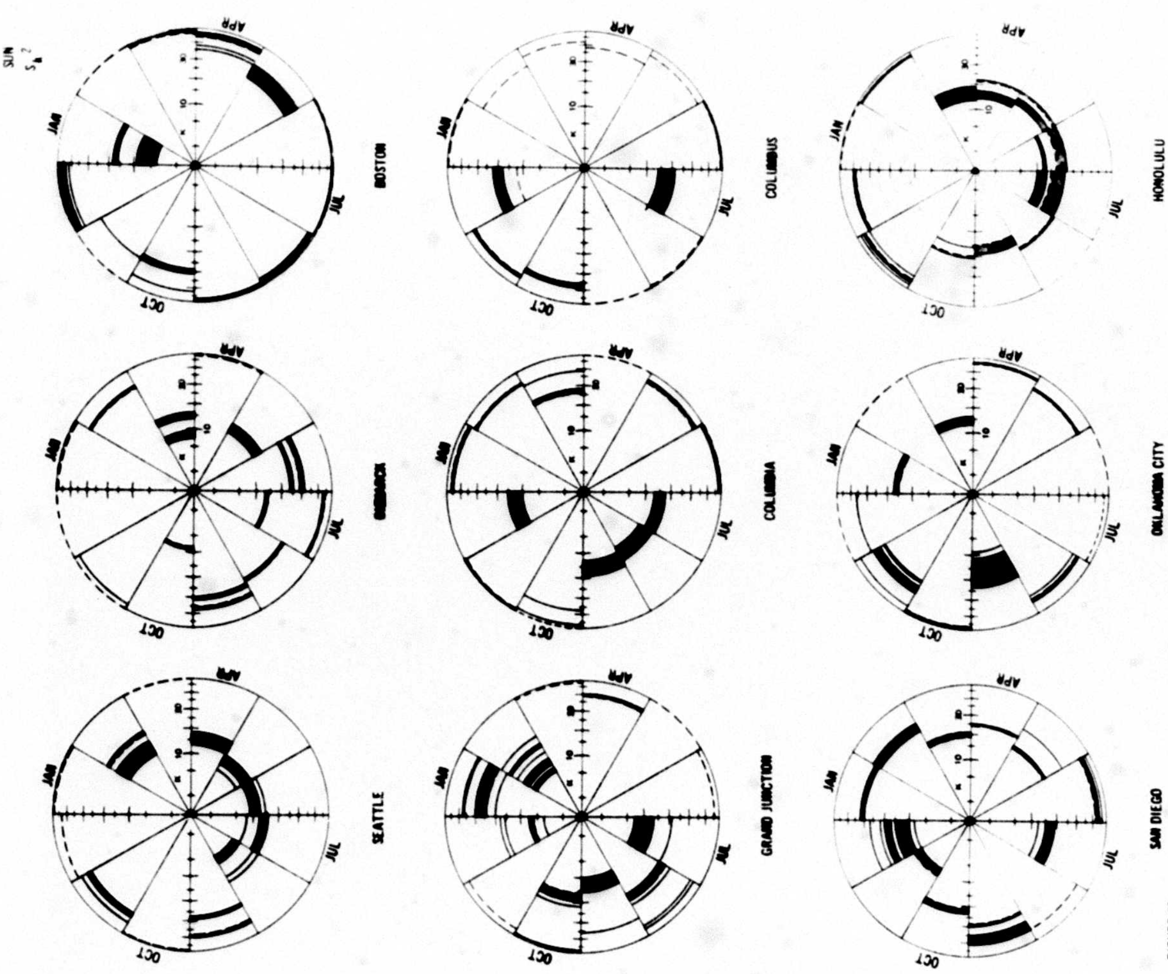

SUN
BOSTON
COLUMBUS
HONOLULU
BISMARCK
COLUMBIA
OKLAHOMA CITY
SEATTLE
GRAND JUNCTION
SAN DIEGO
JAN
APR
JUL
OCT

FIGURE 29

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13. ABSTRACT

The length of the antecedent period for which the mean provides the minimum variance estimate of the next year's temperature, rainfall, and number of rainy days is calculated for a U.S. climatological benchmark station, a variety of foreign stations, and for percent of possible sunshine at U.S. stations. Results verify the findings reported previously, and found by other authors, that the optimum record length varies widely from element to element and month to month, but shows some regional consistency. For all elements, stations, and months combined, all antecedent periods 10 to 40 years long yield averages which, on the whole, are about equal in predictive accuracy.

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PREDICTION, CLIMATIC						
OPTIMUM RECORD LENGTH						

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