AN INVESTIGATION OF THE VARIABILITY AND DISTRIBUTION OF RAINFALL AND SOME RAINFALL ASSOCIATION FOR SELECTED STATIONS IN CARACAS VALLEY, VENEZUELA

A Thesis

by

RICARDO RAFAEL PONTE RAMIREZ

Submitted to the Graduate College of
Texas A&M University in
partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE

December 1970

Major Subject: Meteorology

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(Member)

December 1970

ABSTRACT

An Investigation of the Variability and Distribution of Rainfall
and some Rainfall Association for Selected Stations
in Caracas Valley, Venezuela. (December 1970)

Ricardo Rafael Ponte Ramirez, B.S., Universidad Central de Venezuela
Directed by: Professor Walter K. Henry

This is a study of the temporal and areal variation of the precipitation which occurs within a few kilometers of Caracas, Venezuela. The location is adjacent to the Caribbean Sea, but most of this area is separated from the sea by a range of mountains. Caracas is located on the floor of an interior valley.

Within this small area the variation of rainfall during the year is large with dry periods in which rain occurs and rainy periods which have extended dry spells. These variations were studied by several means. Also the temporal distribution of rain was studied to determine the reliability. Finally, the relationship of one station to others was determined by using the coefficient of association. Maps showing the areal variation of the coefficient of association are included.

The variation of rainfall within this small area is large. Only in gross terms can be rainfall be classified into seasons.

To the Memory of my Father.

ACKNOWLEDGEMENTS

My graduate program was sponsored by the "Corporación Venezolana de Guayana." To Dr. Rafael De Leon of the "Corporación Venezolana de Guayana" a special thanks for his help and understanding during my studies.

I wish to express my sincere appreciation to Professor Walter K. Henry under whose direction this research was performed and for his guidance, stimulation, and assistance during my graduate program.

My thanks are extended to Dr. Robert A. Clark, Dr. Edward A. Hiler, and Dr. Vance E. Moyer for their encouragement and help in the final preparation of the manuscript.

I sincerely express my thanks to Dr. Vance E. Moyer and other faculty and staff members with whom I came in contact during my course of study at the Texas A&M University as a graduate student.

Special thanks to Mr. Jimmy Cain and Mr. Jimmy Shunk for their assistance in preparing computer programs.

To my wife, Maria Dolores, and my son, Diego Eduardo, whose encouragement, support, understanding and patience during the entire period of my graduate study made possible the completion of this task, I extend my deepest appreciation and gratitude.

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CHAPTER I

INTRODUCTION

Rainfall assumes the role of primary importance in the tropics, where the temperature is relatively stable throughout the year and is adequate for plant growth and human activity at all times; indeed, rainfall becomes the determinant of the "seasons" in the tropics. As a consequence, an accurate knowledge of the rainfall distribution at a location is essential for the agricultural, engineering, commercial, and biomedical planning for that area.

The area chosen for this study encompasses Caracas, the capitol of Venezuela. Caracas is located in a 152 km^2 valley surrounded by mountains which are an eastward extension of the Andes. This valley is drained by the Rio Guaire. The lowest point in the east-west oriented valley is 850 m (2,790 ft). The Coastal Range, which lies parallel to the coast, has peaks rising to 2,765 m (9,070 ft), which separate the city from the Caribbean Sea lying 15 km to the north.

An industrial economy prevails throughout most of the area. A comprehensive study using annual and monthly data should reveal rainfall characteristics that can be of climatic value to meteorologists, hydrologists, agriculturists, civil and construction

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engineers, and others, and ultimately benefit the economic development of the area.

Objectives

The primary objectives of this study are to investigate the distribution of annual, monthly, and seasonal rainfall in the Caracas valley and the adjacent areas, to provide a statistical analysis of annual and monthly rainfall variability, and to evaluate the degree of annual and monthly rainfall association.

Review of Literature

A search of the literature on Venezuelan rainfall reveals that most of the previous work performed was for the purpose of arriving at a climatic classification for the country, or to utilize the data in a manner such that the climatic controls (wind systems, intertropical convergence zone, fronts, topography) could be determined.

Gol (1963) made a study of the location of the intertropical convergence zone (ITCZ) and its effect on the precipitation patterns in Venezuela.

Fletcher (1949) made a meteorological analysis of the general rainstorm of June 9-12, 1945, that produced substantial streamflow in the Rio Tuy drainage basin in northern Venezuela. He indicated that the ITCZ, in combination with the orography of the basin, was the weather model responsible for that rain.

Grosske (1967) studied the frequency of frontal invasions into Venezuela for a 10-yr period. He identified 179 cases in which polar fronts from both the Northern and Southern Hemispheres invaded Venezuela. These fronts frequently caused heavy rainfall.

Griffiths (1967) suggested a technique to demonstrate the changes in precipitation from month to month. He considered the difference between the percentage of the annual rainfall observed in two successive months. He suggested that this approach may explain the synoptic influence that causes the increase or decrease of precipitation from one month to another. The approach would point out any seasonal variation. He used this technique for the northern part of South America. Since his study was on a broad scale, detailed terrain effects in Venezuela were not indicated. He also made an evaluation of monthly rainfall for 15 stations in Venezuela. His study utilized values of extremes of rainfall.

Griffiths (1964) also illustrated the statistical technique of measuring rainfall variability and a method of calculating the probability of receiving selected amounts in Central America.

Griffiths (1961, 1963) advocated the application of the normal distribution to annual rainfall and the square-root-normal distribution to monthly rainfall at the tropical stations. He found that 76 per cent of annual totals for Central American stations were distributed normally. In view of this relationship, it is possible to identify the annual rainfall distribution for any station or area by the use of the two parameters - mean ($\bar{X}$) and standard deviation (σ).

Alvarez *et al*. (1969) made a climatic and hydrologic study of the Caracas valley. They drew maps of the mean-monthly and mean-annual precipitation for different periods of time in the valley. They also determined the probability of occurrence of a given amount of rainfall for return periods of 25 and 50 yr.

O'Brien and Griffiths (1967) discussed the problem of testing the hypothesis that small samples belong to a normal population. They showed that for small samples, less than 100, it appears to be sufficient to use only the Cornu criterion and the skewness test to detect departures from normality.

Byers and Riehl (1960) discussed the problem of deriving a design flood for a Venezuelan river without an adequate period of rainfall and streamflow data.

Wisler and Brater (1959) discussed the concept of isopercental analysis of precipitation in regions where rainfall is controlled largely by the topography. They stated that by means of the isopercental method, a comparatively small number of stations can be used to develop a detailed isohyetal map. This technique was applied by Morris (1966) to Colombian stations and by Coligado (1967) to Philippine stations.

The coefficient of association (the square of the product-moment correlation coefficient) was used by Barnard (1965) to study the rainfall in Central America, and Henry (1967) in Guyana and

Surinam. They concluded that the method was a useful tool in investigations of both macroscale and mesoscale meteorological systems. Also, both arrived at the same conclusion, namely, that there was very little association of rainfall even when the stations were close to each other. Henry showed concentric rings of better and less association in Guyana.

CHAPTER II

BACKGROUND

Selection and Limitations of Data

The data for this study were obtained primarily from three sources. They are:

a. Texas A&M Research Foundation Project 645, "Research in Tropical Rainfall Patterns and Associated Meso-Scaled Systems."

b. Instituto Nacional de Obras Sanitarias, División de Hidrología, Caracas, Venezuela.

c. Universidad Central de Venezuela, Central de Datos Geofísicos. Departamento de Meteorología e Hidrología. Archivo de tarjetas perforadas de datos climatológicos.

Rainfall records for 54 stations were available for this study. Most of the stations are located in the Rio Guaire drainage basin. Some are located in the lowlands of the Coastal Range, which lies parallel to the coast. A list of the stations, their location, elevation (m), and number of years of records is attached as Appendix A. The length of record varies from 7 yr to more than 75 yr. Most of the records are for the period 1948 to 1967. Unfortunately, even within this period very few of the records are complete.

With the data being submitted from several sources, there is a chance of error. This possibility should not, however, cause the research to be curtailed. One must be apprised of the fact that the rainfall data used are subject to the same errors as are encountered in any rainfall study. These errors are primarily observational errors and sampling errors.

Observational errors are those having to do with the human factor. Such errors are: improper reading of the rain gage, improper or illegible recording of the data, and inaccurate transmission of the data to the central collection agency. Further, the amount of precipitation lost from the gage by evaporation is not known.

Sampling errors also must be considered. With the very short length of records of some stations, statistical methods do not guarantee significant results. It is considered generally that 40 yr of precipitation observations are necessary to stabilize the statistical parameter of interest. The density of data in some parts of the region under consideration is so sparse that the lines drawn may be interpolations between suspicious values. Hopefully, data which exceed reasonable values were eliminated. Because of the limitations of the data, the temporal and spatial changes in the position of the patterns should give the best indication of rainfall in the valley. The peculiarities and seasonal movements of rainfall can be shown by these patterns.

Climatic Controls

The area under consideration lies at latitudes of approximately 10° 19' N to about 10° 40' N and within longitudes 66° 44' W to

67° 19' W. The topographical feature and relief of the area under study and location of stations are shown in Figure 1.

In general, the wet season in Caracas extends from May until November, and the dry season from December until April. The beginning of both seasons fluctuates from year to year, however, and there are wet periods in the dry season and dry periods in the wet season. There have been occasions when the dry season of one year would have more rainfall than the wet season of another year. The wind direction has a southeasterly component in all seasons. In addition to the topographic and latitudinal effects which materially modify the rainfall patterns, predominantly seasonal air masses blow over the region and must account for some of the peculiar rainfall patterns.

The dominant macroscale systems which previous writers advocate as affecting the weather in Venezuela are: (1) the Intertropical Convergence Zone (ITCZ) and its seasonal oscillations; (2) the orientation of the general wind pattern with respect to the coast; and (3) polar air masses invading the country from both hemispheres. The ITCZ greatly influences the climate of all Venezuela. The ITCZ meanders considerable distances northward and southward with the seasons. According to Riehl (1954), this meandering amounts to 25 degrees of latitude. He states, "In January the mean position ranges from 17° S to 8° N, in July from 2° N to 27° N. The mean latitude is 4° S in January and 13° N in July."

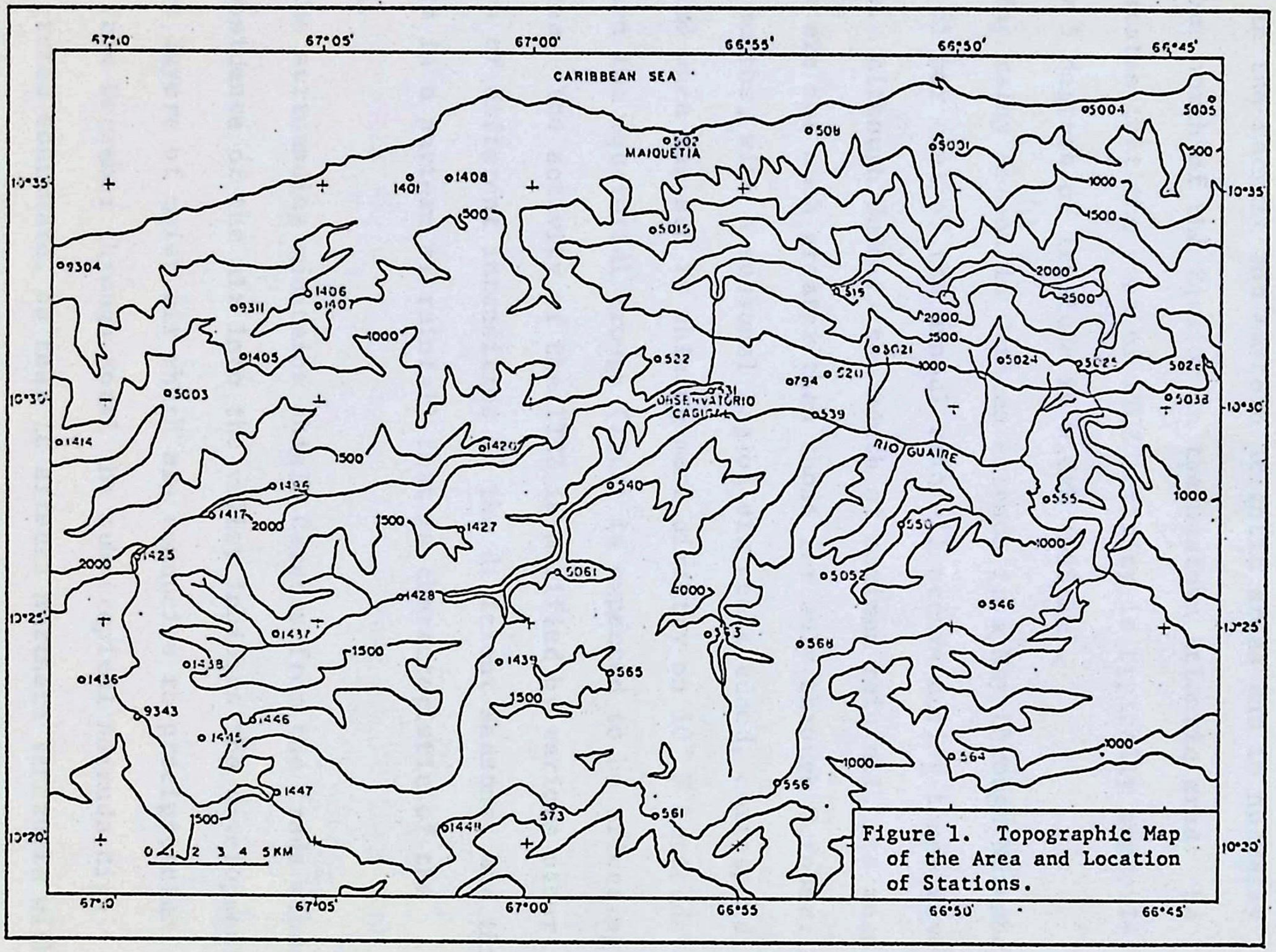

Figure 1. Topographic Map of the Area and Location of Stations.

Johnson (1963), in reporting on the ITCZ as revealed by the Tiros weather satellites, states that the ITCZ is normally near 10° N in the Pacific and eastern Atlantic areas and is normally near but north of the Equator in the western Atlantic area. He also states that the zone of ITCZ activity is typically approximately 5 degrees of latitude in width (555 km).

The rainy season in Caracas extends from May through November. About 85 per cent of the annual rainfall occurs during those seven months. Although June is the month of maximum rainfall, its mean values are not much greater than those for July through October. These months, with a seasonal lag of six weeks added, correspond to the time when the sun is shining most directly on 10° N latitude and when the equatorial trough (ITCZ) is expected to be affecting the area. The activity of the ITCZ is modified by various other factors of different intensities in the different seasons, and this results in a pattern of rainfall that is characteristic of the region.

The surrounding mountains shield Caracas from the trade winds, and subsidence of the air into the valley inhibits the development of deep layers of moist air which are conducive to precipitation. Also, from December through April the sub-tropical Bermuda High has migrated southward, so that it affects northern Venezuela with its trade inversion caused by subsidence aloft. Some mid-latitude cold fronts move to northern Venezuela during the winter months.

CHAPTER III

PROCEDURES OF ANALYSES

Precipitation Changes from Month to Month

The seasonal distribution of rainfall may be presented in many ways. One common method is to present maps with the isohyets for the entire region and, thus, utilize interpolation for areas in which no data are available. But in tropical and mountainous areas, this method presents great difficulty. Another method of showing seasonal rainfall is to give maps of the percentage amount of precipitation falling during each month. This, then, eliminates the real difference between amount recorded at different stations and reduces them all to a common denominator, namely percentages.

The most reasonable technique suggested by Griffiths (1965) is the change in percentages of monthly rainfall. The analysis simply takes the difference between the average rainfall amounts recorded in two successive months and expresses this as a percentage of the annual total. This produces a non-dimensional number, so that stations with small annual totals can be compared strictly with those stations with larger annual rainfall.

This technique was employed because the area being considered has large topographical variations. Also, the simplicity of the procedure, which makes use only of the monthly and annual mean values, allows the use of a large number of stations. Stations with more than eight years have been used for this analysis. Stations with short records will not show the constancy of the mean that is required for such an analysis. It would be better if all stations have more than 30 yr, but paucity of data required that shorter records be used.

The percentage of the mean monthly rainfall with respect to the annual mean values was computed for each month and station. To determine the percentage monthly change, the value of each month was substracted from the percentage value of the preceding month. The difference indicates whether the station is in an increasingly wet (positive) period or in an increasingly dry (negative) period. In this manner one can study the monthly variations in precipitation and, hopefully, can deduce from this the synoptic influences which cause certain regions to experience an increase or a decrease in rainfall. The resulting maps with isopleths of equal percentage changes give an idea of the changing rainfall by months.

Isopercental Analysis

The water year commonly used in Venezuela is the period from March 1 to February 28 of the following calendar year. In view of this, the following grouping of the data seems to suit best a seasonal classification: winter, December through February; spring, March through May; summer, June through August; and autumn, September through November. The same quarterly divisions were used by Morris (1966) and Coligado (1967). It should be emphasized that these divisions do not carry the thermal characteristics commonly used in North America.

Monthly and annual rainfall means for the 54 stations were obtained through programming the IBM 360/65 computer of the Texas A&M University Data Processing Center.

The seasonal percentages of annual rainfall (per cent of mean annual rainfall observed for the respective three-month periods) were calculated for all stations, plotted, and isopercental lines drawn for the ratios at 10 per cent intervals. This method of isopercental analysis has been used extensively by hydrologists and hydrometeorologists in regions where precipitation is controlled largely by topography. The underlying assumption is that while the terrain will alter the amount of rainfall observed at any location, the mechanism causing the precipitation will produce a temporal distribution so that a uniform percentage will be observed within the region being influenced. This technique eliminates the real difference between amount recorded at different stations and reduces them to the common denominator of percentage. Occurrence of a maximum percentage over a large portion of the region during a season may indicate the presence of a synoptic influence.

The isopercental maps for the seasons were combined to reveal regions where seasonal distribution of rainfall is homogeneous. This technique was suggested by Griffiths (1965). For each station, the seasonal percentage was rounded off to the nearest whole 10 per cent in such a way that the sum of seasonal percentages totaled 100 per cent. These seasonal values were coded, e.g., 2341, which means 20 per cent in winter, 30 per cent in spring, 40 per cent in summer, and 10 per cent in autumn. A plot of the coded figures was constructed and areas with identical codes were delineated. The reader has to be aware that the rounding process resulted, in some instances, in a small change of data between the quarterly map and the zoned map. Rounding off was done with a ± 5 per cent maximum. Therefore, 4 per cent in the seasonal map will appear as 0 in the combined map.

Month of Maximum and Minimum Rainfall in the Caracas Valley

Rumley (1965) found that in Ecuador there was a rather smooth progression of the month of the maximum as it traversed the country from west to east. When the same technique was tried by Henry (1965) for Central America the patterns were varied and mixed. However, doubts existed whether this method would apply to a small area like the Caracas valley, i. e., it might not show a trend of progression of month of maximum and minimum rainfall.

This approach utilized only the mean rainfall values. All the 54 stations were used in this analysis. To help avoid the effect of extreme rainfall on any month, the three consecutive monthly means with the greatest total rainfall were identified and the middle month was considered as the month of maximum precipitation. The same procedure was used in determining the driest month. Places with the same month of maximum or minimum rainfall were mapped to show the homogeneous area with respect to the occurrence of maximum and minimum rainfall.

Coefficient of Variation

The coefficient of variation shows the magnitude of deviation of the observed values from the computed mean values. Places of uniform annual or monthly rainfall are expected to exhibit low values and vice versa.

Monthly rainfall data for the 54 stations were available for this investigation. In order to reduce the standard error of the coefficient of variation to a minimum, the square-root transformation suggested by Griffiths (1961) was applied to all the data.

The monthly and annual coefficients of variation were computed for each of the stations using the equations:

$$CV = 100\,\frac{\hat{\sigma}}{\overline{X}}\ ; \quad \hat{\sigma} = \sqrt{\frac{\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{N}}{N-1}}\ ; \quad \overline{X} = \frac{\Sigma X_i}{N}$$

where: CV = coefficient of variation (per cent),

$\hat{\sigma}$ = standard deviation,

X_i = monthly or annual rainfall,

N = number of years or months of record, and

$\overline{X}$ = mean monthly or mean annual rainfall

In the denominator N-1 is used instead of N to represent a better estimate of the standard deviation of a population from which the sample is taken. There is practically no difference for large values of N ($N > 30$).

The values obtained were plotted for all stations and isolines were drawn to delineate areas of equal variability during the particular period (year or month).

The stability and reliability of the values obtained are dependant upon whether all of the samples are of the same size and period, preferably of 20 yr or more. However, the rainfall records available for this area were not sufficient for this rigid requirement to be met. Longley (1952) concluded that the coefficient of variation is affected less by sampling errors, and is satisfactory for comparing variability between stations. Spiegel (1961) stated that a disadvantage of the coefficient of variation is that it fails to be useful when the mean values are close to zero.

Statistical Rainfall Analyses

The areal and temporal variation of rainfall gives an important clue to the diversity of the synoptic patterns that affect a region. For this reason, and so that reliable estimates may be made of the likelihood of chosen rainfall amounts, it is essential to identify the temporal distribution pattern of the data.

In the present investigation of the Caracas valley, it was decided to examine data from each of the 54 stations available in order to discover whether these also presented a distribution not significantly different from normal. A difficulty arises when considering a small sample in that some of the tests are not allowable or not sufficiently powerful. Griffiths (1961, 1963) advocated the application in tropical regions of the normal distribution to annual rainfall and the square-root-normal distribution to monthly regions.

Three statistical significance tests were utilized to ascertain if the assumptions could be made that the annual rainfall data fit a normal distribution and the monthly rainfall data fit a square-root-normal distribution. The tests applied were the Cornu criterion, the skewness test, and the Chauvenet criterion. Brooks and Carruthers, in their Handbook of Statistical Methods in Meteorology (1953), outlined the method that has been used in this investigation. It must be noted that these tests do not provide conclusive evidence of normality. They can show that a distribution is unlikely to be normal, but cannot show, with the same degree of probability, that the distribution is likely to be normal (Brooks and Carruthers, 1953). A short resume of these tests is included in Appendix B.

Coefficient of Association

The coefficient of association was computed using the method described by Barnard (1965). It was utilized to determine associations of annual and monthly rainfall. The coefficient of association (the square of the product-moment correlation coefficient) is given by

$$R^2 = \frac{\left[\sum_{i=1}^{n} (X_i - \overline{X})(Y_i - \overline{Y})\right]^2}{\sum_{i=1}^{n} (X_i - \overline{X})^2 \sum_{i=1}^{n} (Y_i - \overline{Y})^2}$$

where X_i and Y_i are the precipitation amounts at stations X and Y for the selected period in each year, i, and $\overline{X}$ and $\overline{Y}$ are, respectively, mean rainfalls.

The coefficient of association, R^2, provides a proportional measure of the variance in Y that is associated with the variance in X. A coefficient of association of +1.00 indicates that X and Y vary in exactly the same way; that is, they are 100 per cent associated. At the opposite extreme, a value of -1.00 indicates that the variations of X and Y are inversely related. While the sign of R^2 necessarily must be positive, the negative associations are shown by letting R^2 take on the sign of R (the product-moment correlation coefficient).

For a geographical representation to be reliable, all of the samples should be of the same size and for the same period. If part of the record for station X is missing, then, the same period for station Y must be disregarded. The reliability of the association is directly related to the size of the sample. For 5-yr association, R^2 is 95 per cent reliable only for values of $R^2 > 0.60$, and for

20-yr association, it is 95 per cent reliable for $R^2 > 0.20$ (Peatman, 1963).

Stations with less than 5 yr of data were disregarded. The associations were calculated for each station using annual and monthly rainfall data and a selected base station, and the values were plotted on maps. Percentage association was used, defined as 100 R^2, and isolines drawn for values of ± 0, ± 20, ± 50, and ± 80 per cent. These intervals are the same as those chosen by Barnard (1965) and Henry (1967).

CHAPTER IV

PRESENTATION OF RESULTS

Precipitation Changes from Month to Month

It is interesting to note that if a station experiences completely uniform precipitation it would receive about 8.3 per cent of the annual total each month. The changes from month to month would be zero. Therefore, a change of 5 per cent between months would be a significant change, while one of 10 or 15 per cent is very significant.

An example of this change of rainfall from month to month is shown in Figure 2. The interior valley has less rain in December than in November, in fact, a decrease of 6 per cent of the annual total in much of the area. Along the north coast, however, more rainfall occurs in December than during November. This indicates that the north coast and the interior valley are subject to different synoptic conditions. The standard explanation is that fronts from the Northern Hemisphere cause heavy rainfall along the coast, and the cold air is too shallow to cross the mountain range.

There are two areas which deserve further attention. The first is in the northeast along the coast. Station 5004 (Uria) did not show any increase from November to December; however, it is not dry in December. The other area is in the west central part of the map, and north of the ridge of mountains. This area has much less

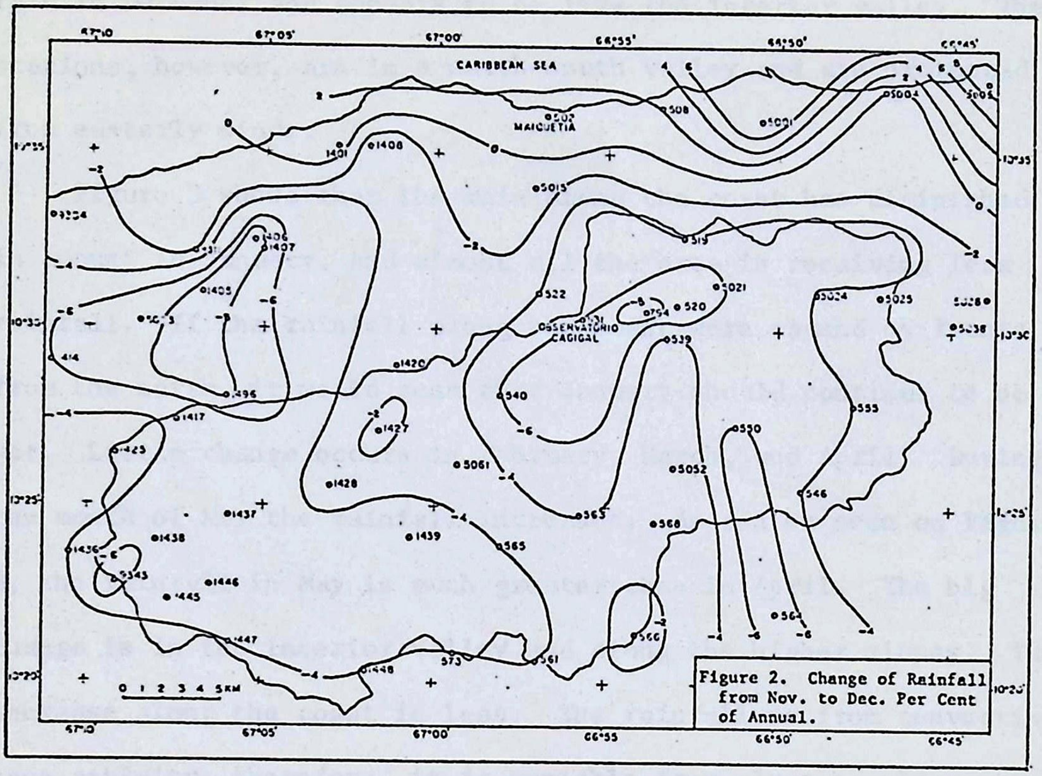

Figure 2. Change of Rainfall from Nov. to Dec. Per Cent of Annual.

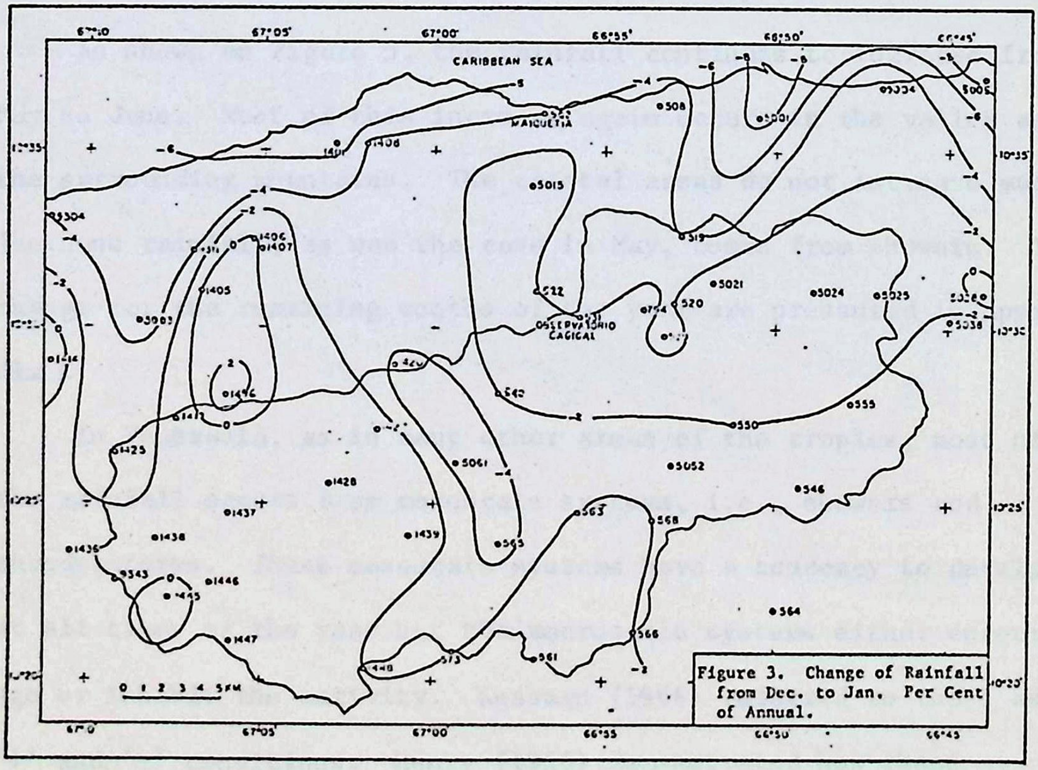

Figure 3. Change of Rainfall from Dec. to Jan. Per Cent of Annual.

rain in December and appears to be like the interior valley. The stations, however, are in a north-south valley and are protected from easterly winds.

Figure 3 shows that the rain along the coast has diminished in amount in January, and almost all the area is receiving less rainfall. If the rainfall along the coast were caused by fronts from the north, it would seem that January should continue to be wet. Little change occurs in February, March, and April. During the month of May the rainfall increases. As can be seen on Figure 4, the rainfall in May is much greater than in April. The big change is in the interior valley and along the higher slopes. The increase along the coast is less. The rainfall is from convective type activity, therefore, it is variable from place to place.

As shown on Figure 5, the rainfall continues to increase from May to June. Most of this increase again occurs in the valley and the surrounding mountains. The coastal areas do not increase much. The June rainfall, as was the case in May, comes from showers. The change for the remaining months of the year are presented in Appendix C.

In Venezuela, as in many other areas of the tropics, most of the rainfall occurs from mesoscale systems, i.e., showers and thunderstorms. These mesoscale systems have a tendency to develop at all times of the year but the macroscale systems either encourage or inhibit the activity. Lessman (1966) referred to these as '+' and '-' conditions. Henry (1966) demonstrated how these

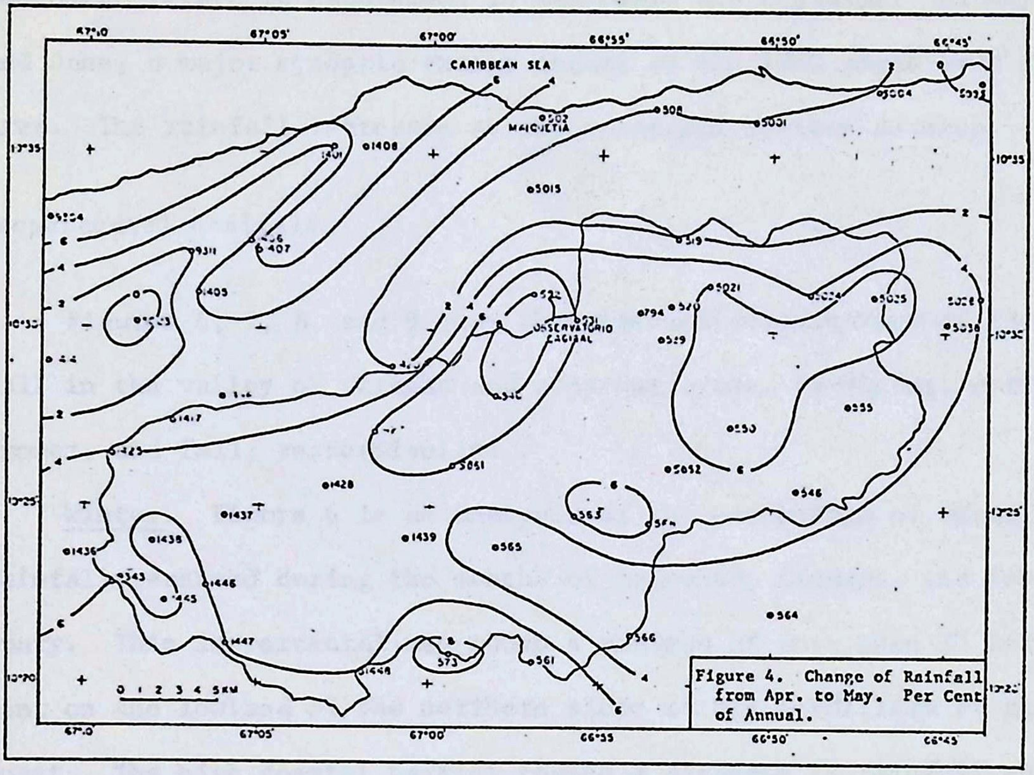

Figure 4. Change of Rainfall from Apr. to May. Per Cent of Annual.

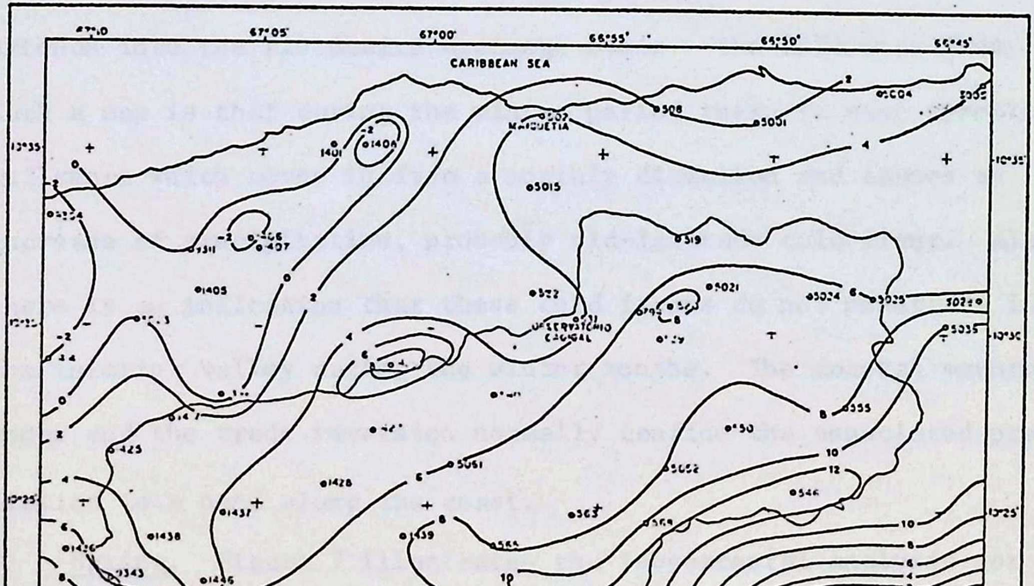

Figure 5. Change of Rainfall from May to Jun. Per Cent of Annual.

phenomena relate to each other in Guatemala and Honduras. In May and June, a major synoptic change occurs as the ITCZ moves over the area. The rainfall increases as the mesoscale systems develop.

Isopercental Analysis

Figures 6, 7, 8, and 9 show the seasonal distribution of rainfall in the valley of Caracas and adjacent areas, in winter, spring, summer, and fall, respectivelly.

Winter. Figure 6 is an analysis of the percentage of annual rainfall received during the months of December, January, and February. This isopercental map shows a maximum of more than 25 per cent on the lowland of the northern slope of the Cordillera of the Coast. The high coastal barrier causes a decrease in rainfall which extends into the Rio Guaire drainage basin. The inference from such a map is that during the winter period there is some synoptic influence which moves in from a northly direction and causes an increase of precipitation, probably mid-latitude cold front. Also, there is an indication that these cold fronts do not penetrate into the interior valley during the winter months. The coastal mountain range and the trade inversion normally confine the associated precipitation to a band along the coast.

Spring. Figure 7 illustrates the isopercental analysis for the months of March, April, and May. During these months the area within the interior valley receives an increase of precipitation. The rainbearing synoptic disturbance, perhaps the ITCZ, has moved

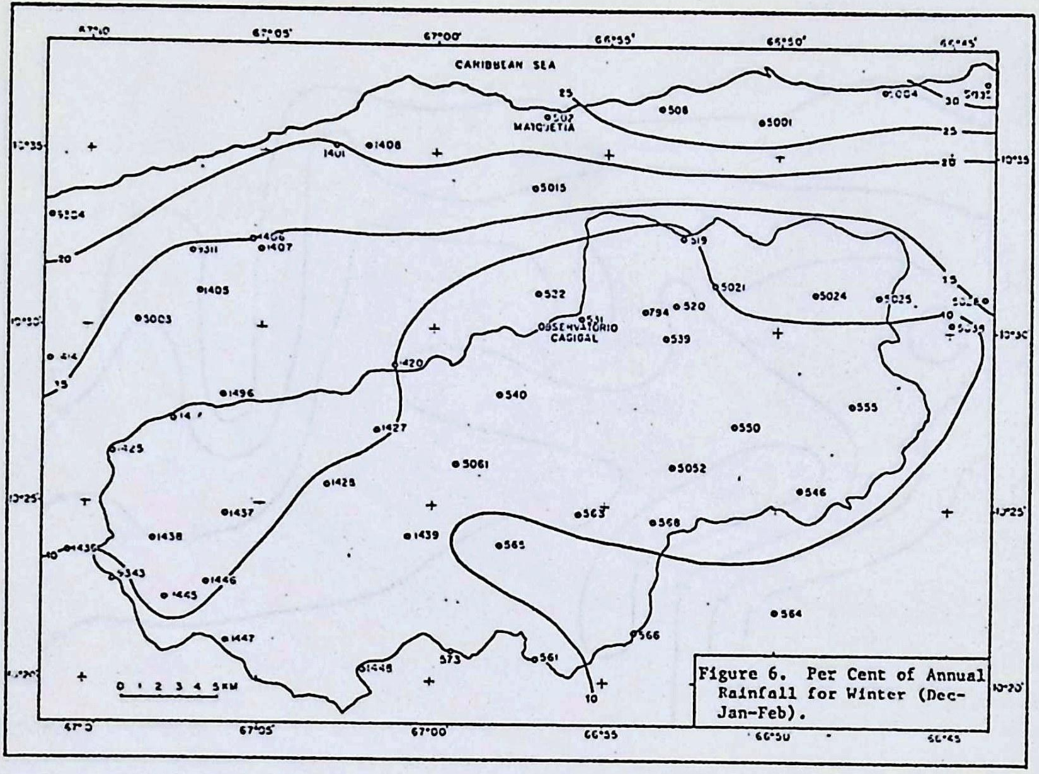

Figure 6. Per Cent of Annual Rainfall for Winter (Dec-Jan-Feb).

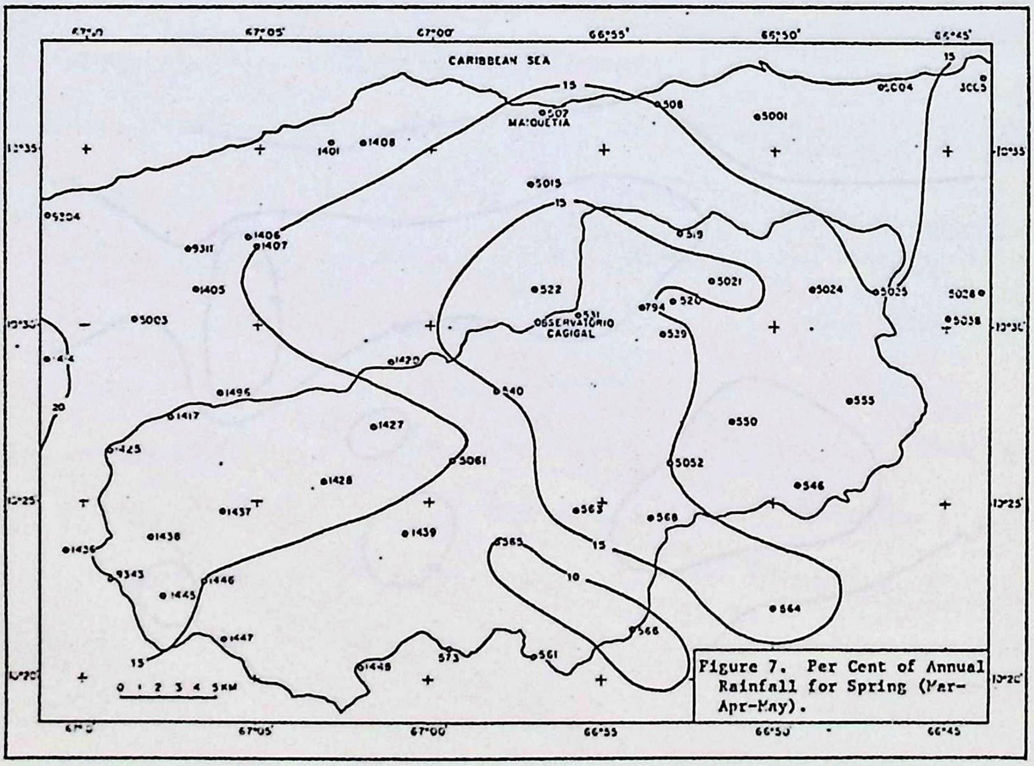

Figure 7. Per Cent of Annual Rainfall for Spring (Mar-Apr-May).

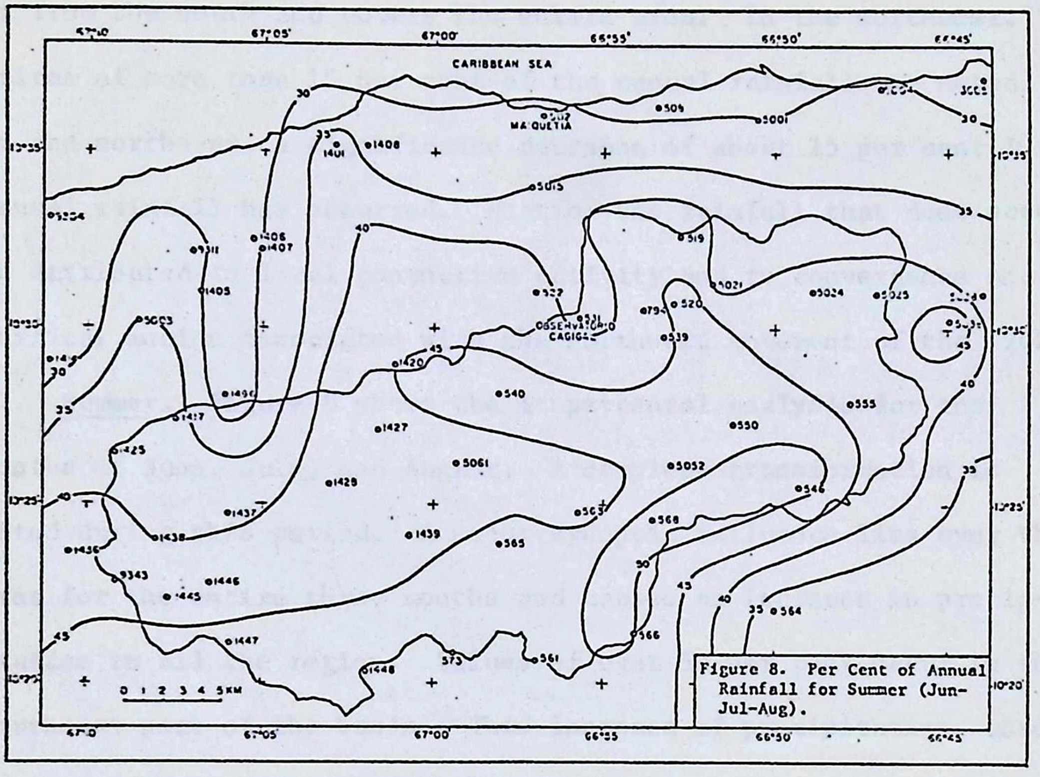

Figure 8. Per Cent of Annual Rainfall for Summer (Jun-Jul-Aug).

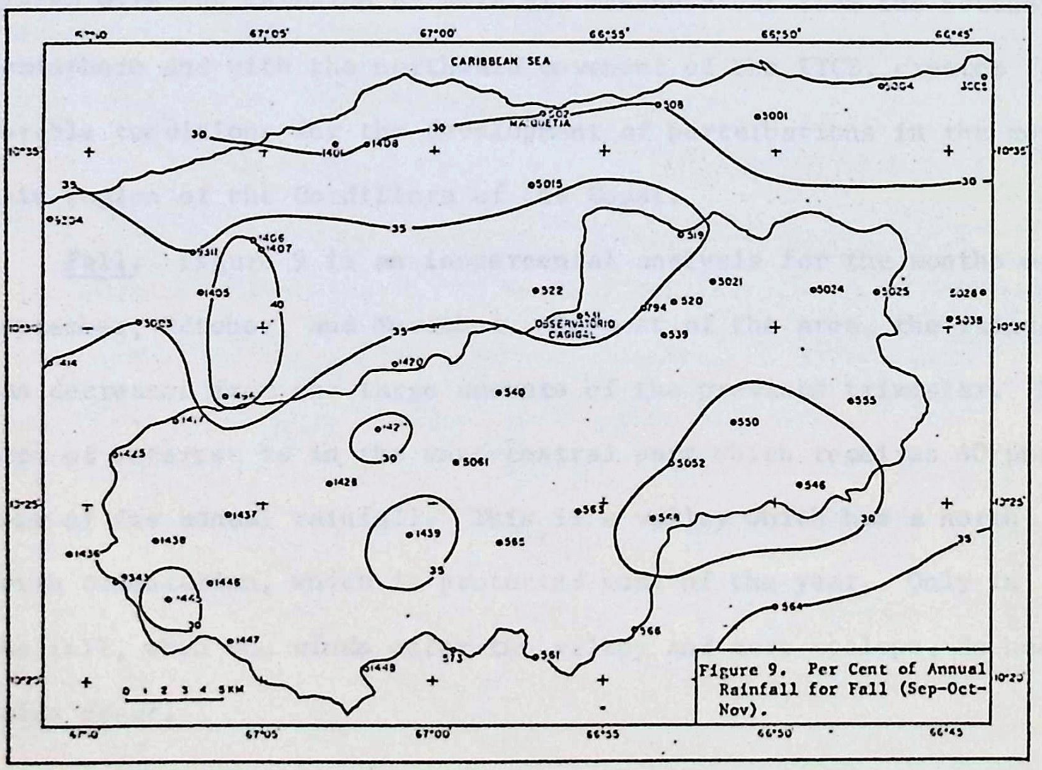

Figure 9. Per Cent of Annual Rainfall for Fall (Sep-Oct-Nov).

in from the south and covers the entire area. In the northwest, values of more than 15 per cent of the annual rainfall are noted. In the northeast, a significance decrease of about 15 per cent in annual rainfall has occurred. Most of the rainfall that does occur is attributed to local convective activity and to convergence and vertical motion associated with the northward movement of the ITCZ.

Summer. Figure 8 shows the isopercental analysis for the months of June, July, and August. A complete transformation is noted during this period. A major synoptic influence lies over the area for the entire three months and causes an increase in precipitation in all the region. Values of over 50 per cent occur in the southeast part of the basin. This increase of precipitation, associated with the invasion of cold air masses aloft from the Southern Hemisphere and with the northward movement of the ITCZ, creates favorable conditions for the development of perturbations in the mountain region of the Cordillera of the Coast.

Fall. Figure 9 is an isopercental analysis for the months of September, October, and November. In most of the area, the rainfall has decreased from the large amounts of the previous trimester. The area of interest is in the west-central part which receives 40 per cent of its annual rainfall. This is a valley which has a north-south orientation, which is protected most of the year. Only in the fall, when the winds enter the valley and move upslope, do heavy rains occur.

Zones of Seasonal Rainfall

Figure 10 delineates regions of homogeneous seasonal rainfall distribution. The greatest and most widespread rainfall is associated with local disturbances developing in conjunction with the ITCZ. The migration of this low-pressure zone is evident in the seasonal distribution. In winter when the ITCZ is farthest south, close to the equator, only the northern slopes next to the ocean have more than 10 per cent of their annual rainfall. In the spring, only those stations which are located on slopes having southern exposure have an increase of rainfall.

During the summer and early fall, the ITCZ, which is associated with an invasion of cold air masses from the Southern Hemisphere, has moved to a most northerly position. This northward movement is revealed by an increase of percentage of rainfall of 10 to 30 per cent over different parts of the region. All areas hold at 30 to 40 per cent.

From this analysis it can be inferred that the great diversity of patterns certainly shows that the rainfall is not uniform in either amount or time in this small region of Venezuela.

Months of Maximum and Minimum Rainfall in the Caracas Valley

Figures 11 and 12 show homogeneous areas with respect to the occurrence of maximum and minimum rainfall. The months of maximum rainfall have a rather smooth progression as they traverse the

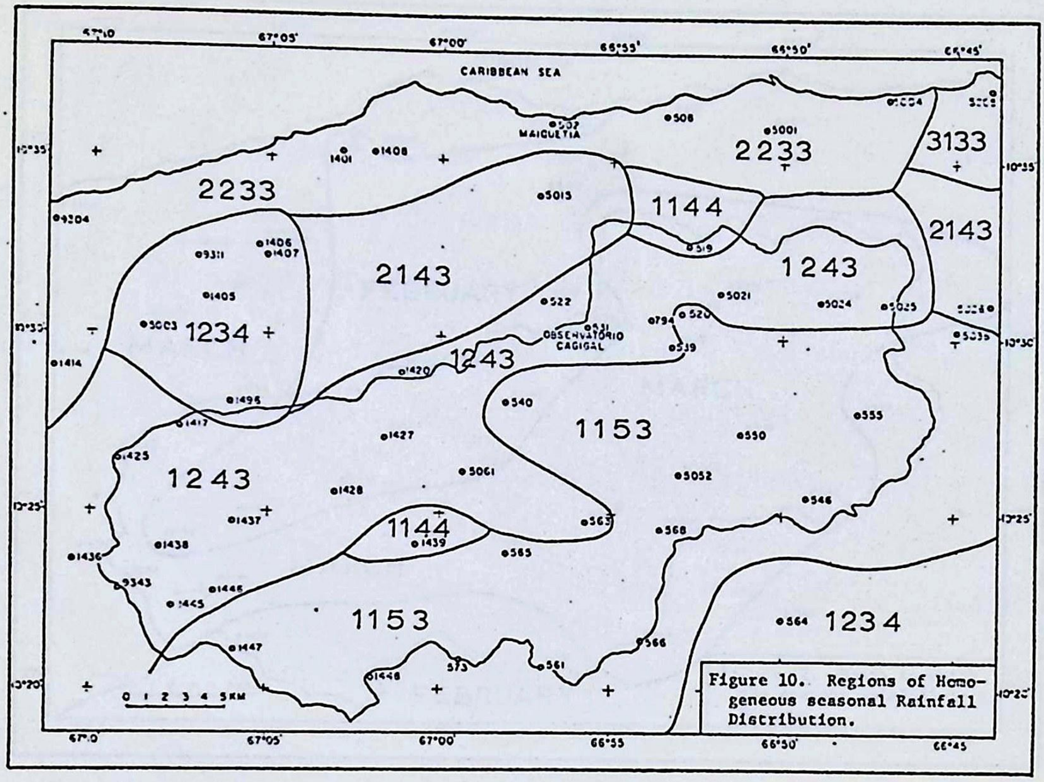

Figure 10. Regions of Homogeneous seasonal Rainfall Distribution.

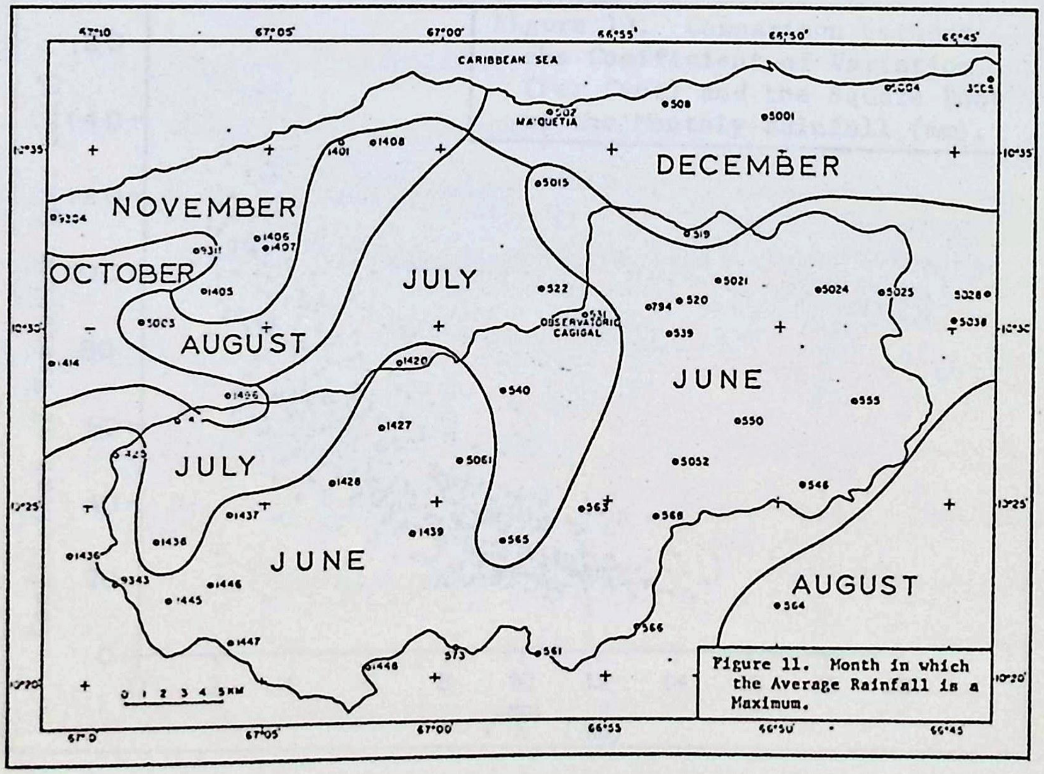

Figure 11. Month in which the Average Rainfall is a Maximum.

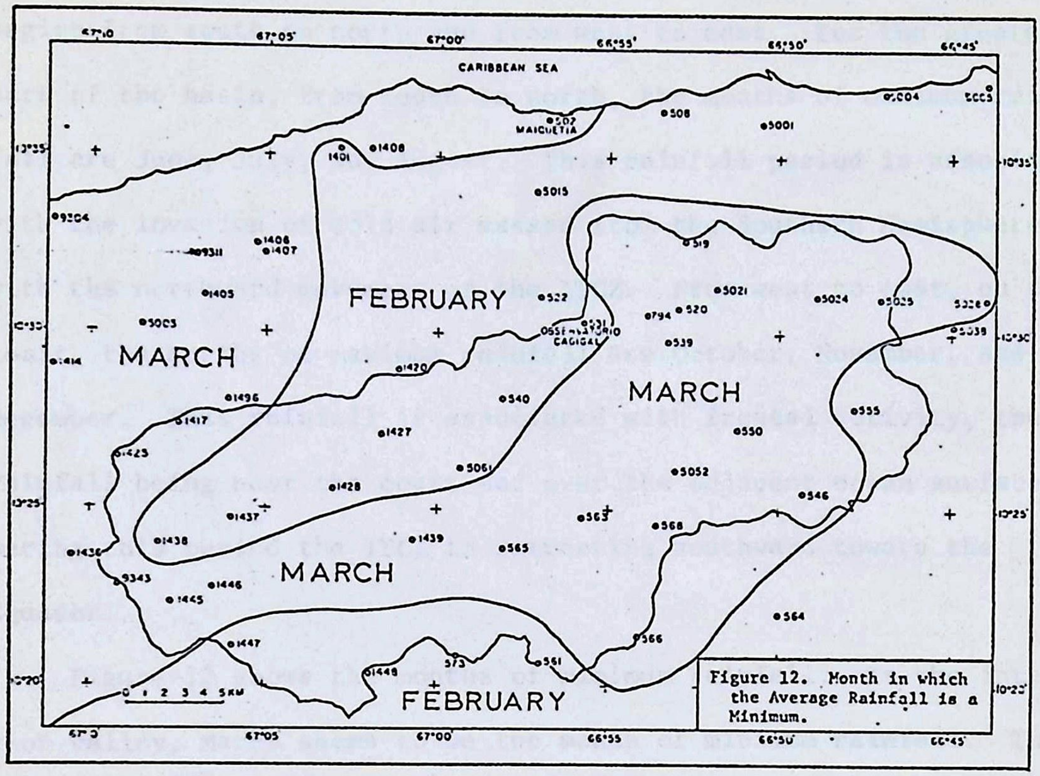

Figure 12. Month in which the Average Rainfall is a Minimum.

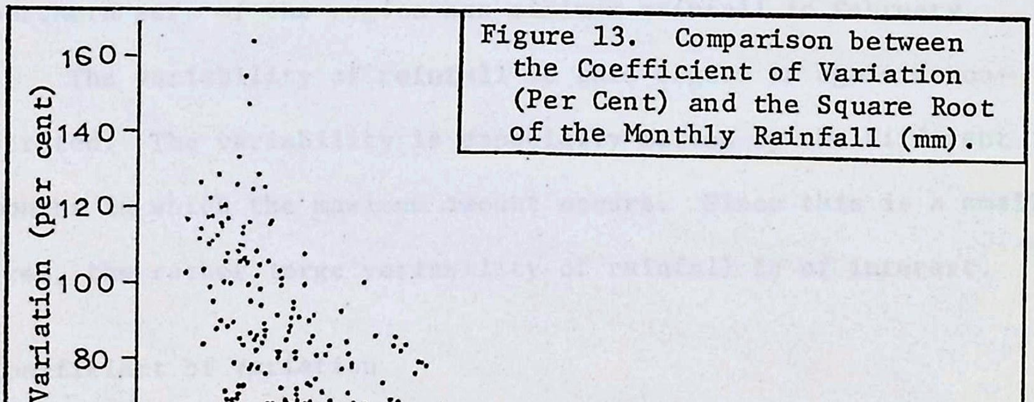

Figure 13. Comparison between the Coefficient of Variation (Per Cent) and the Square Root of the Monthly Rainfall (mm).

region from south to north and from west to east. For the greatest part of the basin, from south to north, the months of maximum rainfall are June, July, and August. This rainfall period is associated with the invasion of cold air masses from the Southern Hemisphere with the northward movement of the ITCZ. From west to east, on the coast, the months of maximum rainfall are October, November, and December. This rainfall is associated with frontal activity, the rainfall being near the coast and over the adjacent ocean surface. During this period the ITCZ is retreating southward toward the Equator.

Figure 12 shows the months of minimum rainfall. In the interior valley, March seems to be the month of minimum rainfall. The northern part of the region has minimum rainfall in February.

The variability of rainfall in this region is again demonstrated. The variability is especially marked by the different months in which the maximum amount occurs. Since this is a small area, the rather large variability of rainfall is of interest.

Coefficient of Variation

As stated previously, the value of the coefficient of variation is not only a function of the different rainfall amounts, but also is a function of the mean rainfall for the station. This is illustrated in Figure 13. The mean of the square roots of the rainfall was used to condense the abscissa of the diagram. It can be seen that when the coefficient of variation is large (> 100 per cent) the rainfall is small. Likewise, small values of the coefficient are associated with the large rainfall amounts.

A map of the areal distribution of the coefficient of variation for July is presented as Figure 14. July is one of the rainier months and, as expected, the values of the coefficient are all less that 100 per cent. Only on some of the mountain slopes is the variation large. Figure 15 shows the areal distribution for February, one of the drier months. As can be seen, many of the areas exceed 100 per cent. However, on both maps the same geographic areas have the greatest variation of rainfall. This indicates that some areas have more variability than others. This variability undoubtedly relates to the terrain and exposure of the station. The maps for the rest of the months are shown in Appendix D.

The areal variation of the coefficient of variation for annual rainfall is presented as Figure 16. In the course of a year, the extremes of one month are smoothed somewhat and the mean is larger; therefore, the values of the coefficient are not as large. From Figure 16, the indications are that the interior valley has a relatively uniform distribution and the greatest variations are north of the coastal range. Rather large monthly values of the coefficient of variation indicate that rainfall is highly variable at a station, exactly the conditions expected when the precipitation results from mesoscale systems.

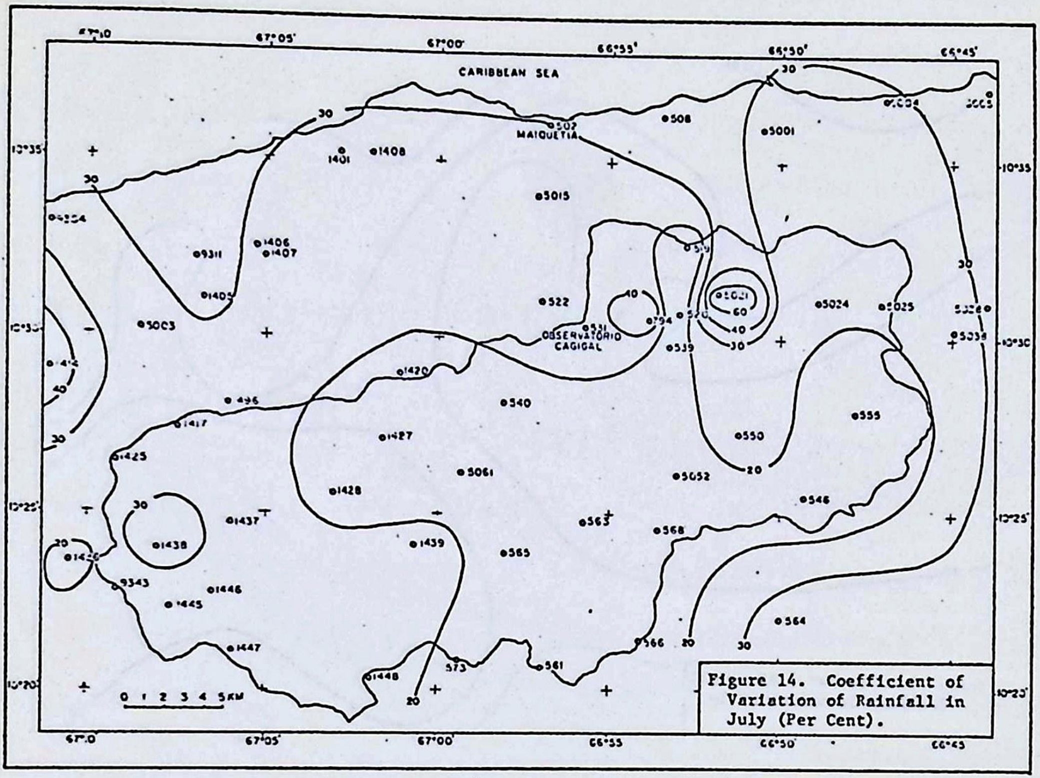

Figure 14. Coefficient of Variation of Rainfall in July (Per Cent).

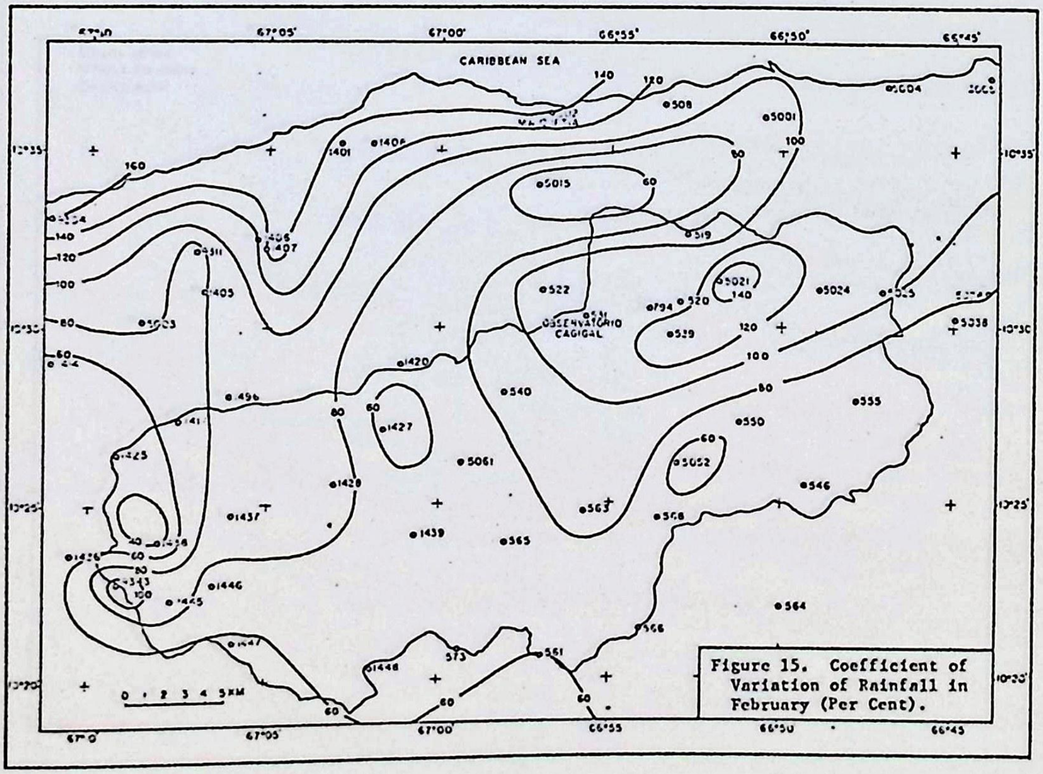

Figure 15. Coefficient of Variation of Rainfall in February (Per Cent).

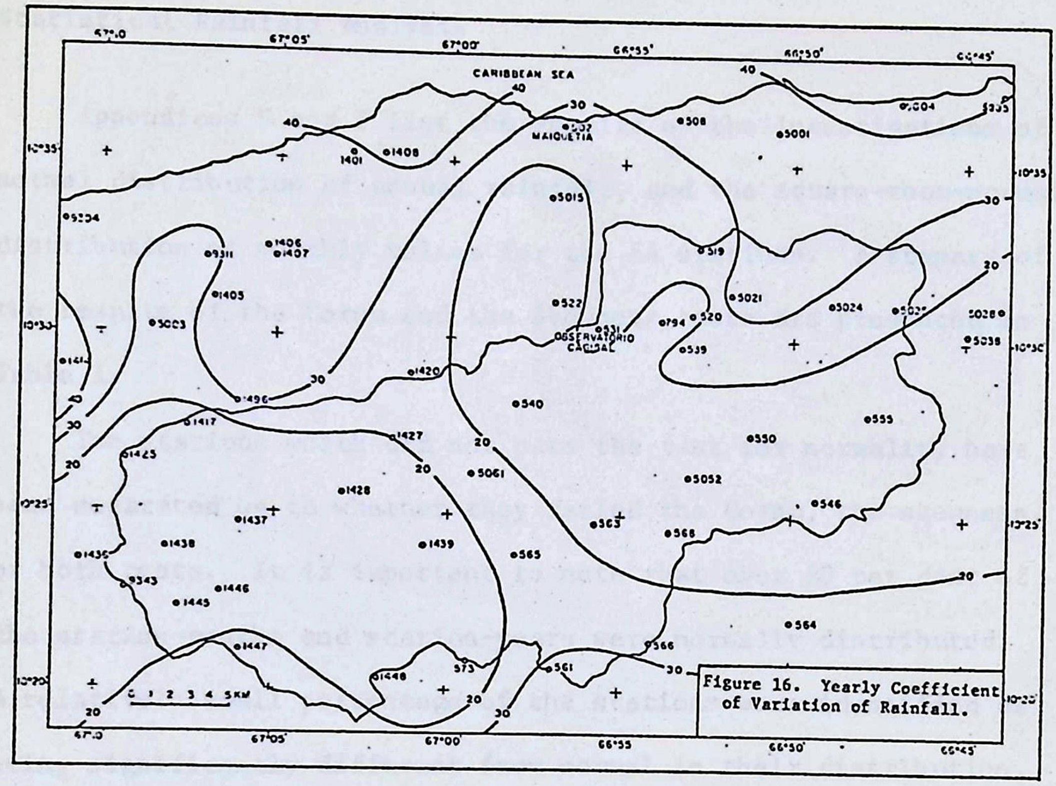

Figure 16. Yearly Coefficient of Variation of Rainfall.

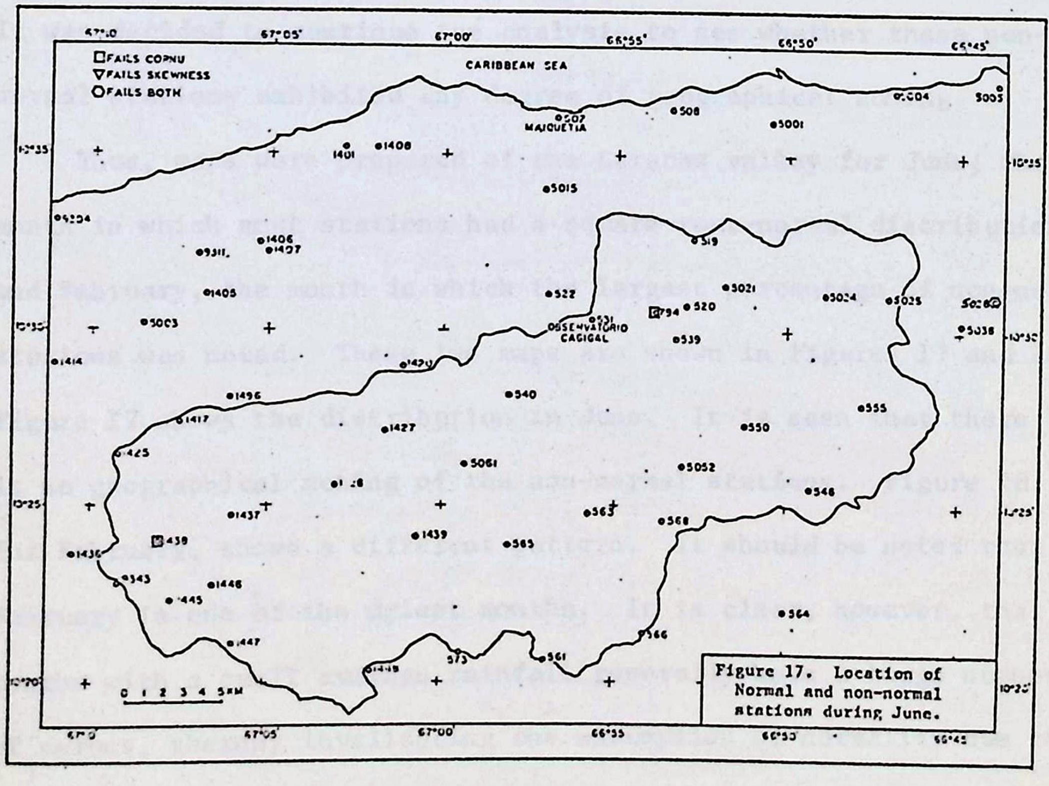

Figure 17. Location of Normal and non-normal stations during June.

Statistical Rainfall Analysis

Appendices E and F list the results of the investigations of normal distribution of annual rainfall, and the square-root-normal distribution of monthly values for the 54 stations. A summary of the results of the Cornu and the Skewness tests are presented in Table 1.

The stations which did not pass the test for normality have been separated as to whether they failed the Cornu, the skewness, or both tests. It is important to note that over 80 per cent of the station-months and station-years were normally distributed. A relatively small percentage of the stations were identified as being significantly different from normal in their distribution. It was decided to continue the analysis to see whether these non-normal stations exhibited any degree of geographical zoning.

Thus, maps were prepared of the Caracas valley for June, the month in which most stations had a square-root-normal distribution, and February, the month in which the largest percentage of non-normal stations was noted. These two maps are shown in Figures 17 and 18. Figure 17 shows the distribution in June. It is seen that there is no geographical zoning of the non-normal stations. Figure 18, for February, shows a different pattern. It should be noted that February is one of the driest months. It is clear, however, that months with a small average rainfall generally have a large number of zeroes, thereby invalidating the assumption of normality due to

Table 1. Totals of Summary of Cornu and Skewness Tests.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Number Normal	41	31	43	49	44	51	44	46	39	40	43	51	44
Per Cent Normal	76	57	80	91	81	94	81	83	72	74	80	94	81
Failed only Cornu	3	3	2	5	10	2	7	6	9	1	7	3	7
Failed only Skewness	4	3	7	0	0	0	0	1	0	0	1	0	2
Failed Both	6	17	2	0	0	1	3	1	6	2	3	0	1

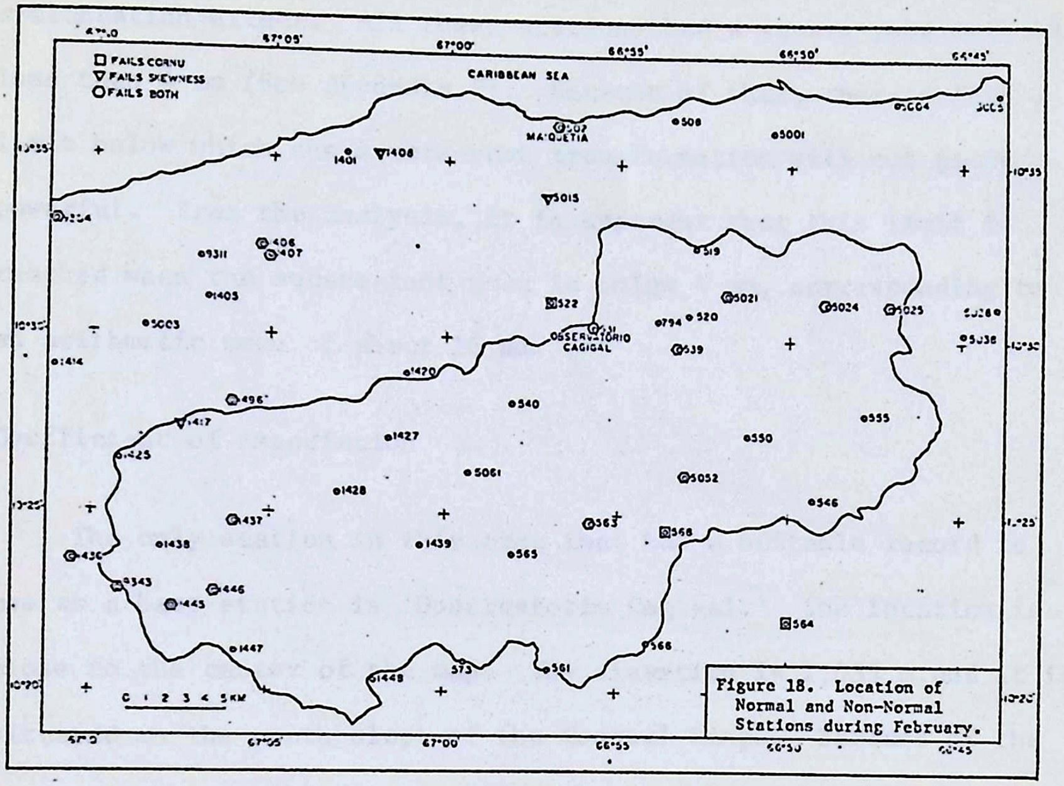

Figure 18. Location of Normal and Non-Normal Stations during February.

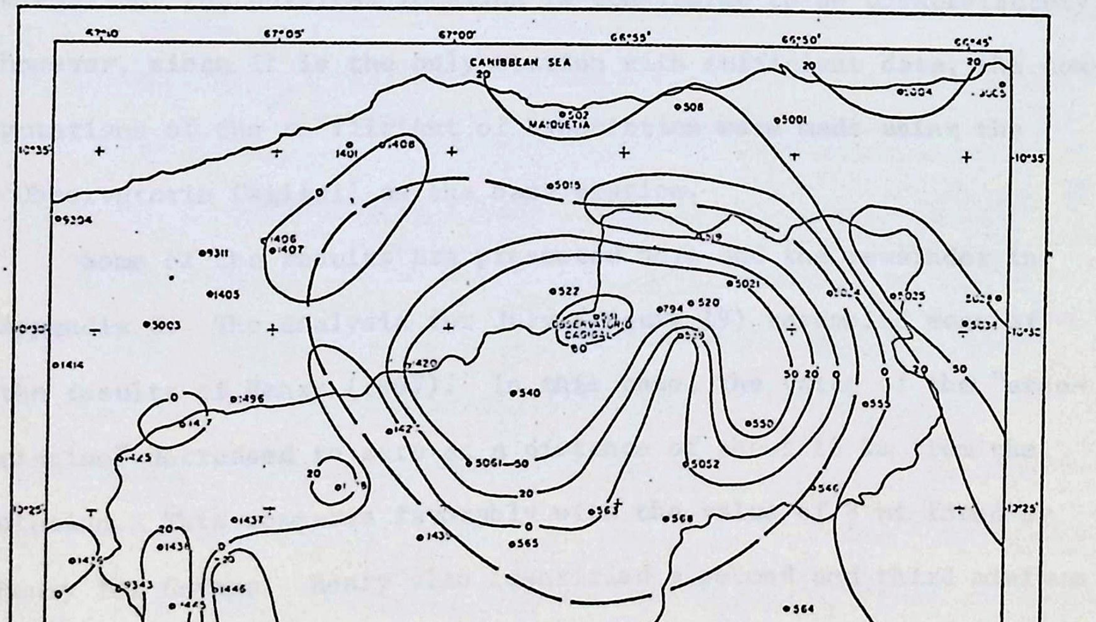

Figure 19. Coefficient of Association for July.

a truncation effect. All these stations had a square-root mean of less than 4 mm (See Appendix F). Because of this, there exists a limit below which the square-root transformation will not prove powerful. From the analysis, it is apparent that this limit is reached when the square-root mean is below 4 mm, corresponding to an arithmetic mean of about 16 mm.

Coefficient of Association

The only station in this area that has a suitable record to use as a base station is 'Observatorio Cagigal.' The location is close to the center of the map. The elevation is 1,035 m and it is situated on the south slope of the Coastal Range. Because of the elevation, the physical location is considered to be unsatisfactory; however, since it is the only station with sufficient data, the computations of the coefficient of association were made using the 'Observatorio Cagigal' as the base station.

Some of the results are presented here and the remainder in Appendix G. The analysis for July (Figure 19) resembled most of the results of Henry (1967). In this case, the value of the "association" decreased to zero at a distance of about 12 km from the station. This compares favorably with the value of 8 mi found by Henry for Guyana. Henry also identified a second and third minimum of association with distance from the station. These additional minima were not identified in Figure 19. This is probably because of the mountain ranges. Morris (1967) did not find the closed rings

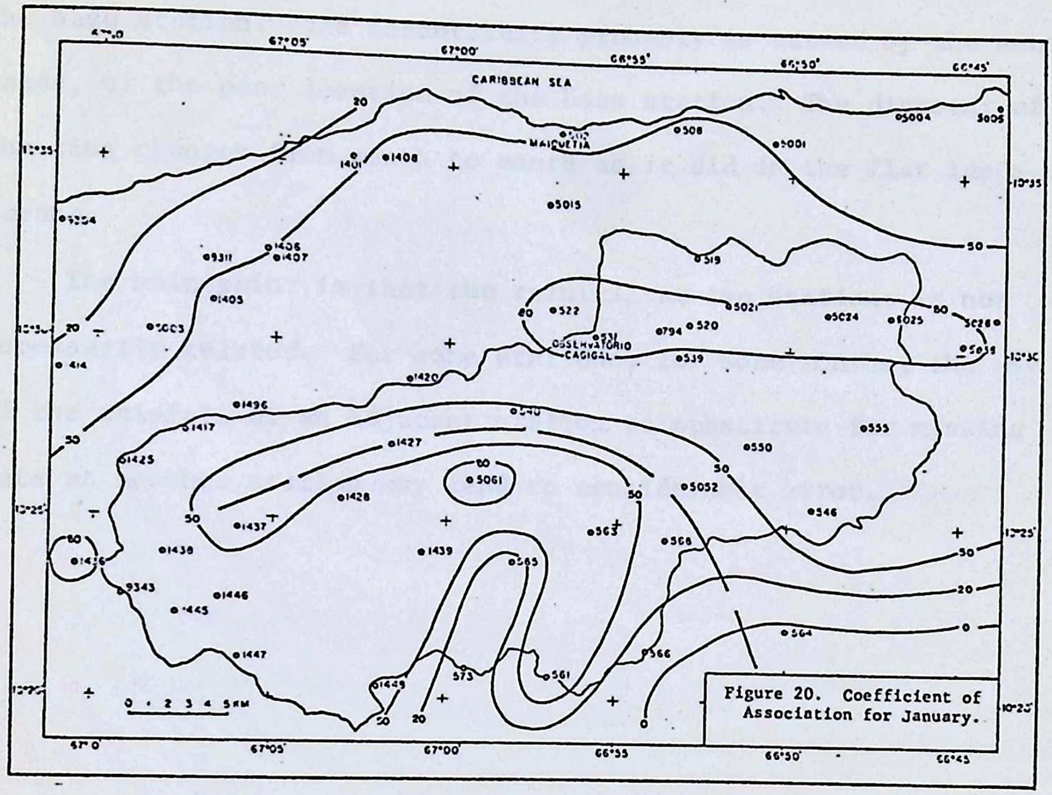

Figure 20. Coefficient of Association for January.

in the mountains of Colombia.

Henry found that the highest values of association resulted during the drier months in Guyana. This also is true for this area of Venezuela. The reason is that during the dry months, rain only occurs when a major synoptic event occurs. Therefore, all stations in the area have similar conditions. The map of the "association" for January (Figure 20) shows that most of the area has a value greater than zero. Also the good association along the ridge, both east and west of 'Observatorio Cagigal,' is an unusual pattern. A tendency for a trough of low association does exist but it cannot be analyzed as a ring about the base station. Most of the other months do have an eccentric ring of low association around the base station. The eccentricity probably is caused by the mountains, or the poor location of the base station. The diameter of the ring changes from month to month as it did in the flat lands of Guyana.

The main point is that the rainfall at two stations is not necessarily related. For some stations, for some months, the use of the rainfall at an adjacent station to substitute for missing data at another station may lead to considerable error.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

As a consequence of the study of rainfall patterns in the Caracas valley, the following conclusions are drawn:

(1) The mesoscale activity associated with the ITCZ is the primary factor in the rainfall occurring in Caracas.

(2) The month-to-month changes in rainfall give indication that synoptic changes are taking place.

(3) The method of isopercental analysis is a satisfactory means of mapping the rainfall distribution and allows for a technic of analysis of the rainfall pattern that minimizes the orographic effects. The method is useful for the purposes of investigating synoptic scales of weather systems, such as the arrival of the ITCZ.

(4) The coefficient of variation, based on yearly data, did not show as much diversity as the values based on monthly totals. The coefficient of variation was found to be generally low in areas where mean precipitation is high (Figure 13). However, areas of high values should be reviewed carefully when planning for water usage.

(5) Annual totals of rainfall at stations in this region may be assumed to be normally distributed. There are about nine chances in ten that this is a correct supposition. The distribution of monthly rainfall totals may be assumed to

follow the square-root-normal pattern when the mean for the month is above 25 mm. When totals are less, there is not a simple mathematical distribution which fits the data.

(6) Rainfall variability increases or decreases greatly over small distances in rugged terrain. It is apparent that relatively small changes in topography greatly alter the rainfall patterns. The practice of using one or two stations for an area such as the Caracas valley will not give a correct picture.

Recommendations

Further study along the following lines is suggested:

(1) The effects of orography can be studied by making comparisons of rainfall records of stations located in adjacent areas but at different elevations.

(2) Further study of the synoptic-scale phenomena is needed, along with their effects on mesoscale systems.

(3) Sufficient synoptic data (surface and upper-air) should be collected to coordinate with the rainfall data in determining the dominant system.

It is hoped that this study may serve as a guideline for further study of the Caracas valley climate, particularly its rainfall.

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APPENDIX A

A list of the selected stations with their location, elevation (m), and number of years of record.

Station Number	Name	N Lat.	W Long.	Height (m)	Years of Record
0502	Maiquetia	10°36'	66°56'	45	12
0508	Macuto	10°36'	66°53'	45	12
0519	Teleferico	10°32'	66°52'	2125	8
0520	La Salle	10°30'	66°52'	1016	7
0522	Catia	10°31'	66°57'	965	11
0531	Cagigal	10°30'	66°55'	1035	77
0539	Ciudad Universitaria	10°29'	66°53'	864	16
0540	Hda. Montalban	10°28'	66°58'	913	9
0546	El Hatillo	10°25'	66°49'	1143	10
0550	La Guairita	10°27'	66°51'	1031	9
0555	Petare	10°28'	66°47'	500	11
0561	San Diego	10°20'	67°55'	1298	13
0563	La Mariposa	10°24'	66°55'	995	17
0564	El Naranjal	10°22'	66°50'	1050	15
0565	Altos de Pipe	10°23'	66°58'	1728	12
0566	El Almendro	10°21'	66°53'	1288	9
0568	Lecherito	10°25'	66°54'	1374	9
0573	Carrizal	10°20'	66°59'	1278	9
0794	La Paz	10°31'	66°54'	918	5
1401	Mamo	10°35'	67°03'	250	10
1405	Caoma	10°31'	67°06'	861	17
1406	Mamo-Estanque	10°32'	67°05'	450	24
1407	Mamo-Planta	10°32'	67°05'	289	26
1408	Marapa	10°35'	67°03'	23	24
1414	Hda. Las Mercedes	10°29'	67°11'	1200	7

Station Number	Name	N Lat.	W Long.	Height (m)	Years of Record
1417	Alto Izcaragua	10°27'	67°07'	2102	10
1420	Loma de Cafetal	10°28'	67°01'	1679	9
1425	Alto No Leon	10°26'	67°09'	2113	14
1427	Sabaneta	10°25'	67°02'	1350	16
1428	Macarao	10°25'	67°03'	1063	13
1436	Agua Fria	10°23'	67°10'	1743	14
1437	Llano de Cura	10°24'	67°06'	1276	13
1438	El Arado	10°23'	67°09'	1800	13
1439	El Carite	10°24'	67°00'	1065	12
1445	Topo de los Espejos	10°22'	67°07'	1671	19
1446	Sitio Oropeza	10°22'	67°06'	1621	15
1447	Pozo de Rosas	10°21'	67°06'	1548	10
1448	Los Teques	10°20'	67°01'	1189	15
1496	Petaquire	10°28'	67°06'		18
5001	Caraballeda	10°36'	66°50'	153	8
5003	Corralito	10°30'	67°08'	1472	12
5004	Uria	10°37'	66°47'	60	15
5005	Naiguata	10°37'	66°44'	60	10
5015	Cerro Grande	10°34'	66°54'	930	12
5021	Chacaito	10°31'	66°51'	1205	18
5024	Subida Pico Avila	10°31'	66°49'	1250	15
5025	El Vigia	10°31'	66°48'	1700	18
5028	Macanillal	10°31'	66°44'	1250	12
5038	Hda. Ayala	10°30'	66°53'	886	13
5052	Baruta	10°26'	66°52'	1012	11
5061	Caricuao	10°26'	66°59'	946	11
9304	Pto. Oricao	10°33'	67°11'	7	15
9311	Carayaca	10°32'	67°07'	893	10
9343	El Jarillo	10°23'	67°09'	1747	12

APPENDIX B

Statistical Tests for a Normal Distribution

Cornu's Criterion

The Cornu criterion studies the relationship between the mean deviation $|e|$ and the standard deviation σ of a series of numbers giving limits for the ratio between the two, so that a distribution may be tested for normality. Then if the distribution is normal, $|e|/\sigma = 0.80$. (Limits depending upon size of sample and degree of probability required.)

Geary (1935), cited by Griffiths (1961), has given the 95 per cent limits for this ratio. They are:

N	10	20	30	40	50	70	100
Upper Limit	0.92	0.83	0.86	0.85	0.85	0.84	0.83
Lower Limit	0.71	0.73	0.74	0.75	0.75	0.76	0.77

If, therefore, the ratio $|e|/\sigma$ falls outside these limits, there is only one chance in twenty that the distribution is normal, and this is generally rejected. If, however, it falls within these limits, all that can be said is that it can be normal.

Skewness Test

For this test, γ_1, the skewness, is calculated together with its standard error. Then, the ratio $\gamma_1/\text{s.e } \gamma_1$ is studied.

For a normal distribution, γ_1 should be zero. If the ratio exceeds 1.96, there again is only one chance in twenty of this stemming from a normal population. Actually, in this case, we may asses a probability of normality from the ratio value.

γ_1/s.e. γ_1	1.0	1.5	1.8	2.0	2.5	3.0
Probability of normality	0.32	0.13	0.07	0.045	0.012	0.003

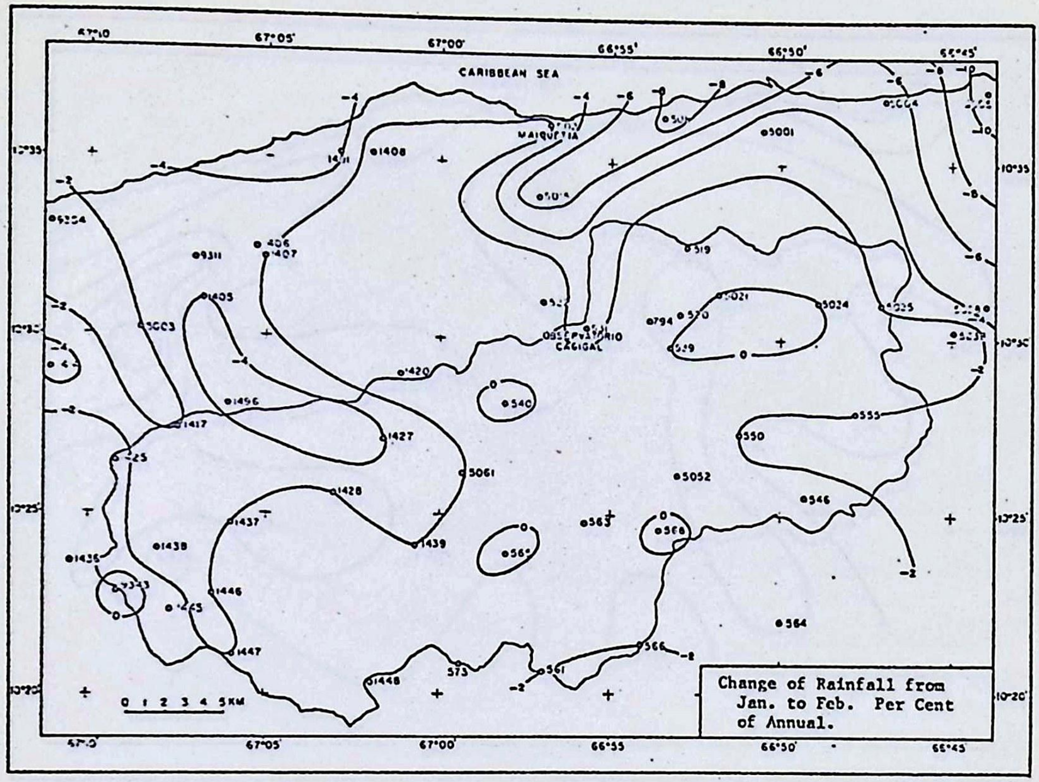
Again, if the ratio is less than 1.96, the only deduction is that the distribution does not differ significantly from normal.

Chauvanet Criterion

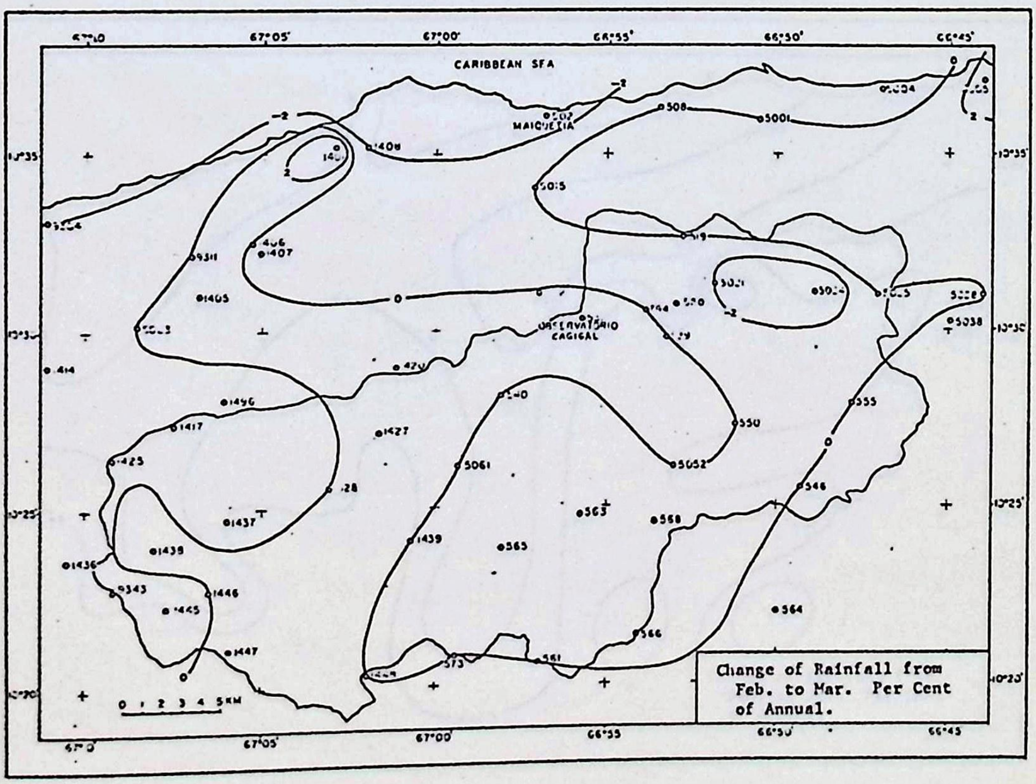
This was used to test a suspected normal distribution for abnormal extreme values. Given N observations with a standard deviation σ, one can compute a value of $|X_{iex} - \overline{X}|/\sigma$, where X_{iex} is the value giving the greatest deviation from the mean. With special tables showing $|X_{iex} - \overline{X}|/\sigma$ corresponding to different values of N (at the 95 per cent level) the determination of normality can be accepted or rejected. The standardized value of each extreme, that is, the maximum or minimum value with the greatest departure from the mean, is calculated for each station. This then can be compared with the value of the Chauvenet criterion corresponding to the given sample size. When each month and year for every station has been analyzed, the results are summarized for the region.

APPENDIX C

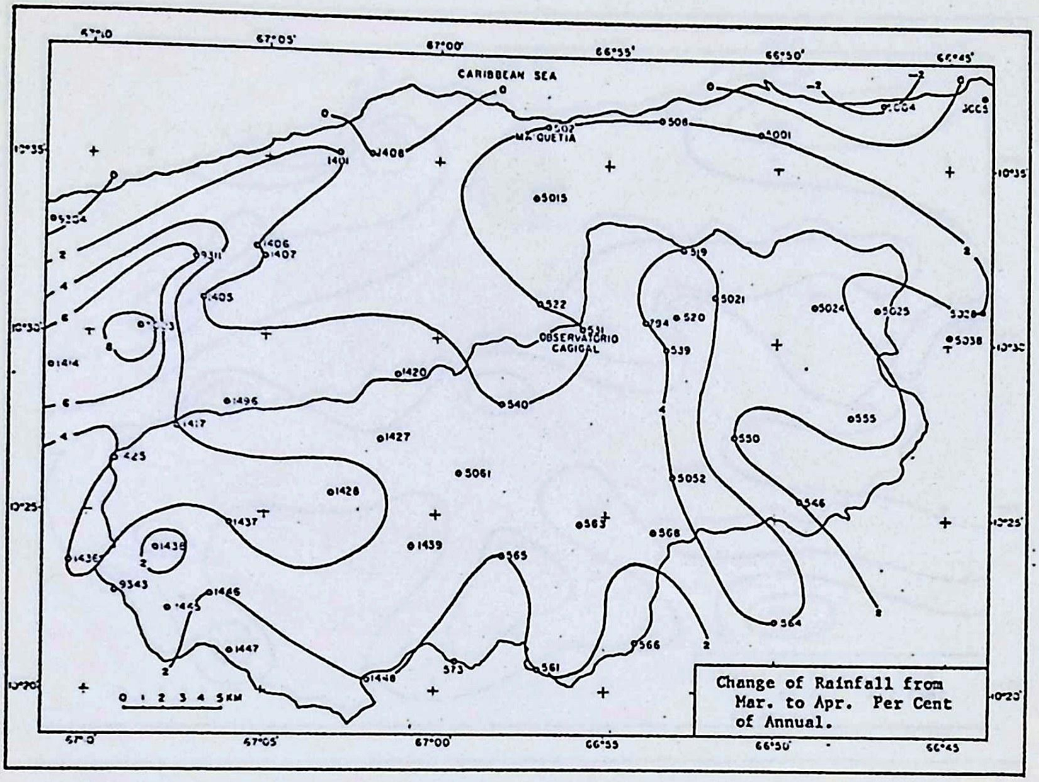
Maps showing the Change of Rainfall from Month to Month expressed as Per Cent of Annual Total



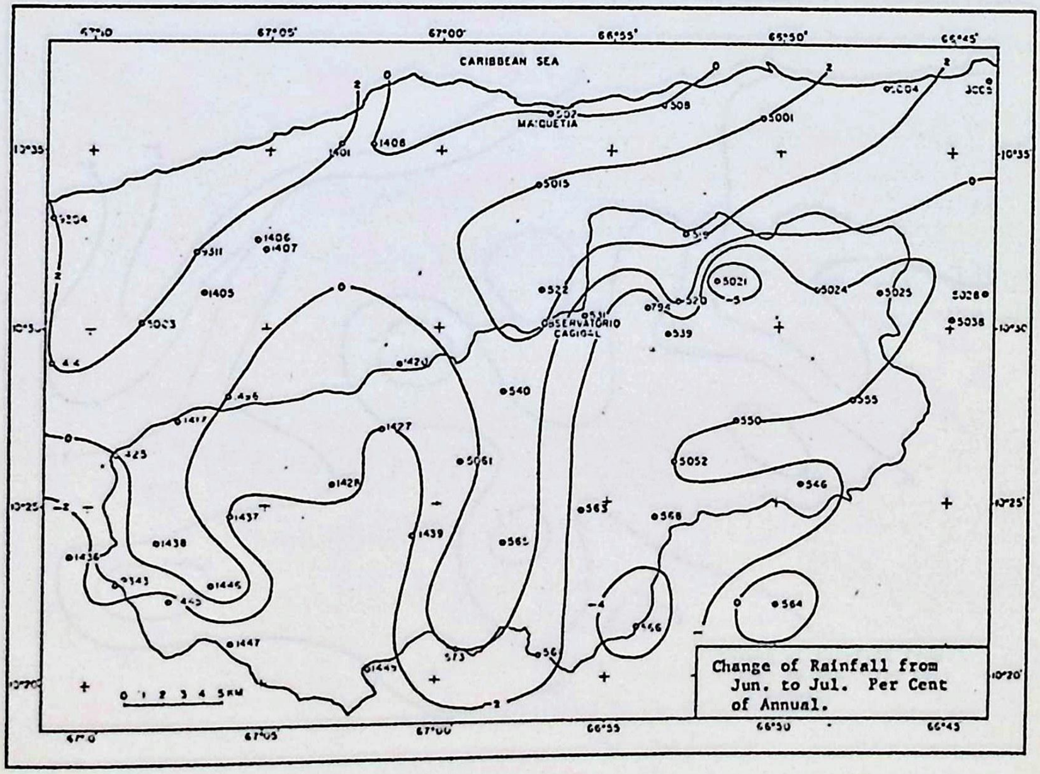
Change of Rainfall from Jan. to Feb. Per Cent of Annual.



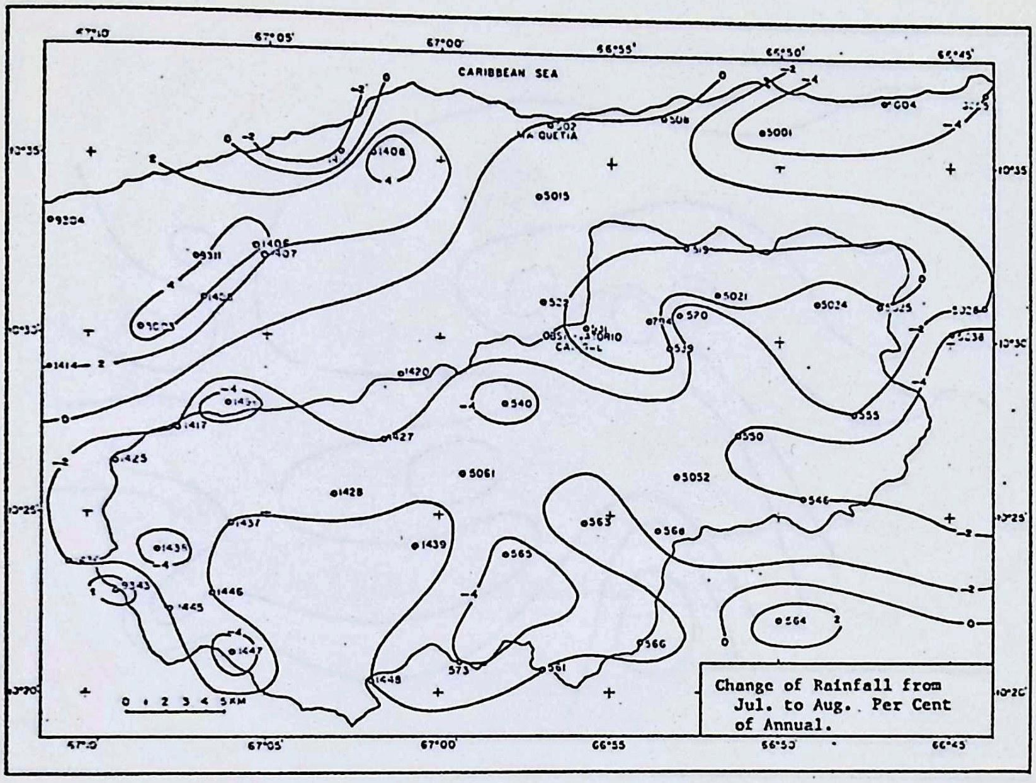
Change of Rainfall from Feb. to Mar. Per Cent of Annual.



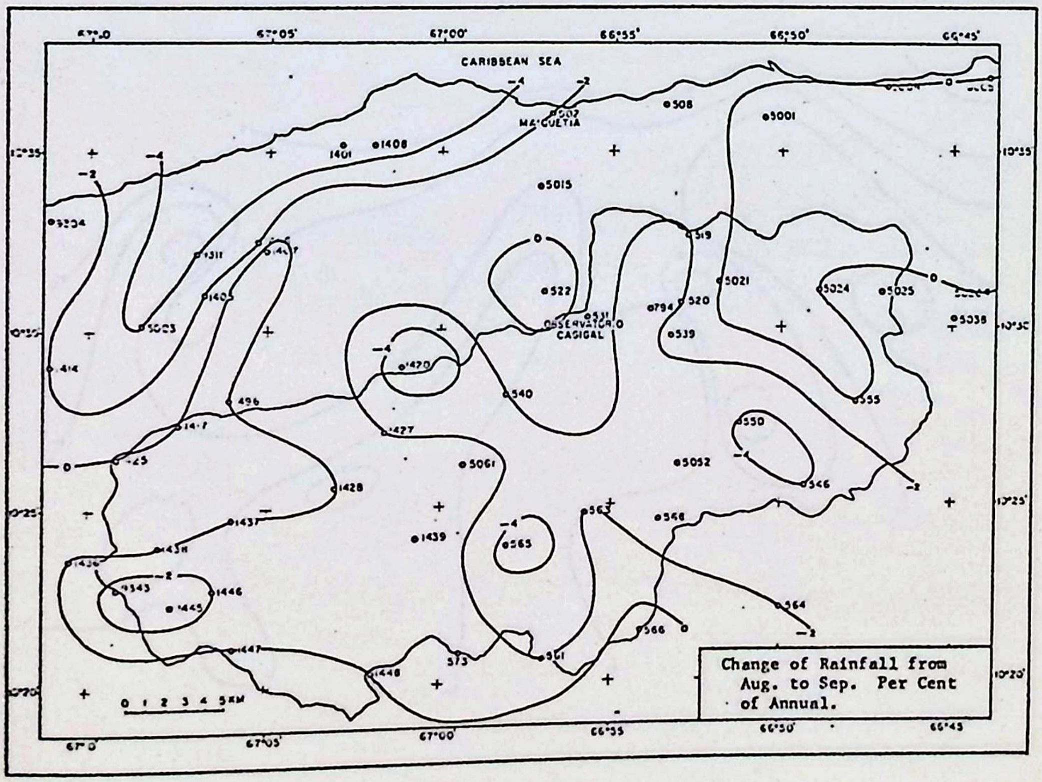
Change of Rainfall from Mar. to Apr. Per Cent of Annual.



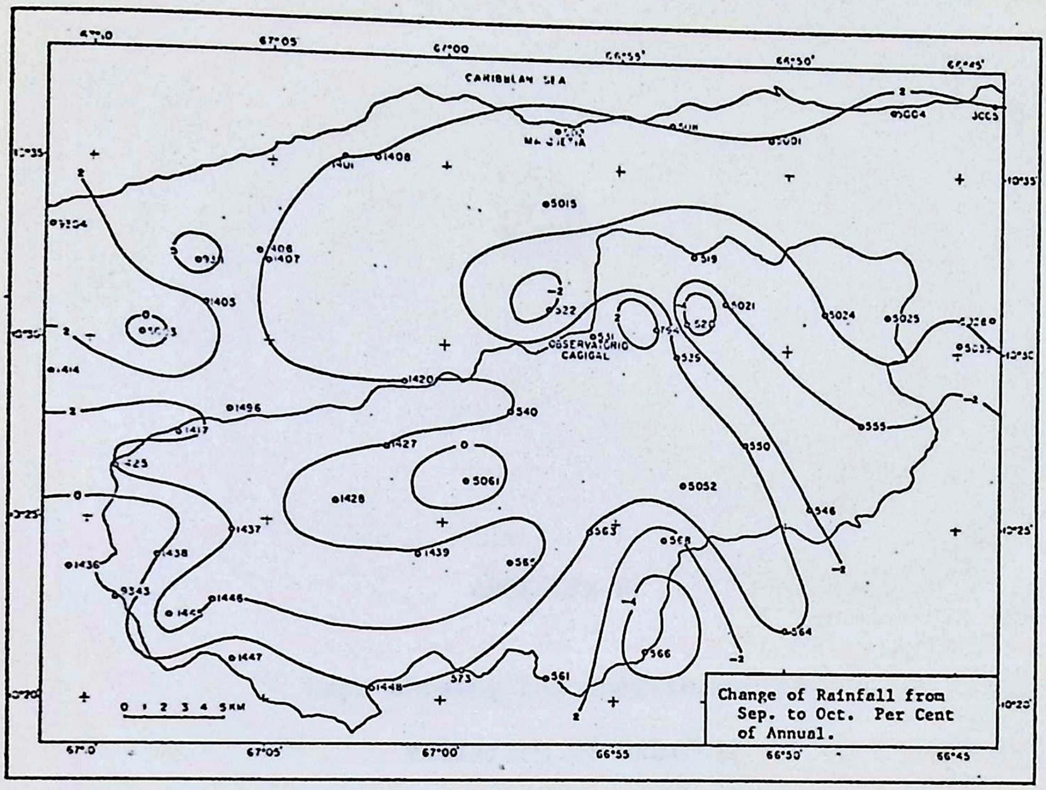
Change of Rainfall from Jun. to Jul. Per Cent of Annual.



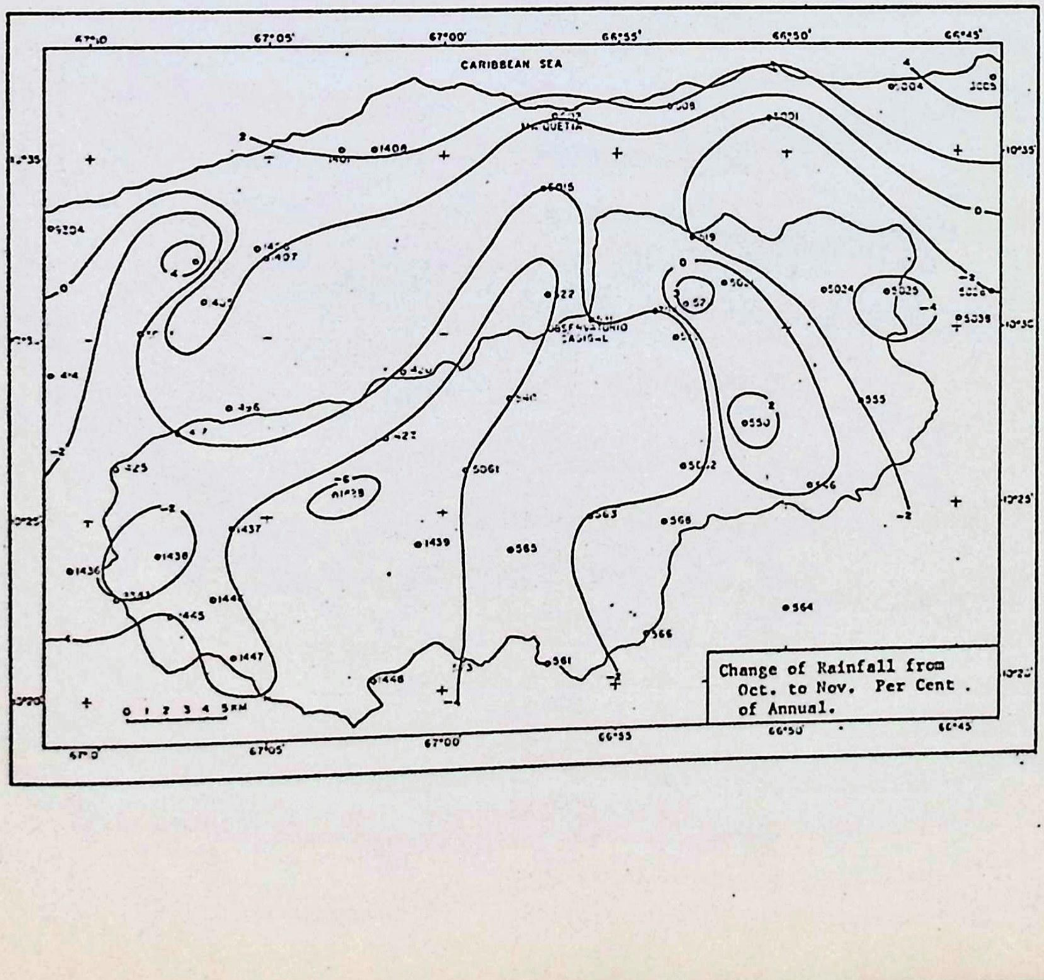
Change of Rainfall from Jul. to Aug. Per Cent of Annual.



Change of Rainfall from Aug. to Sep. Per Cent of Annual.



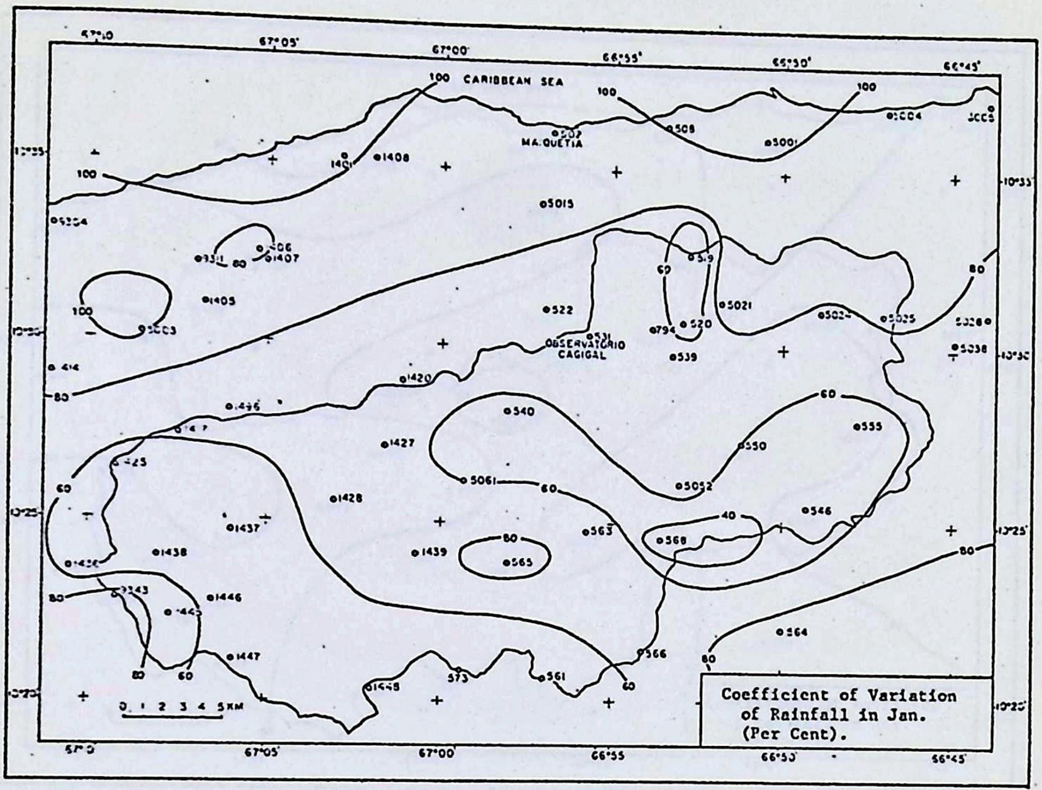
Change of Rainfall from
Sep. to Oct. Per Cent
of Annual.



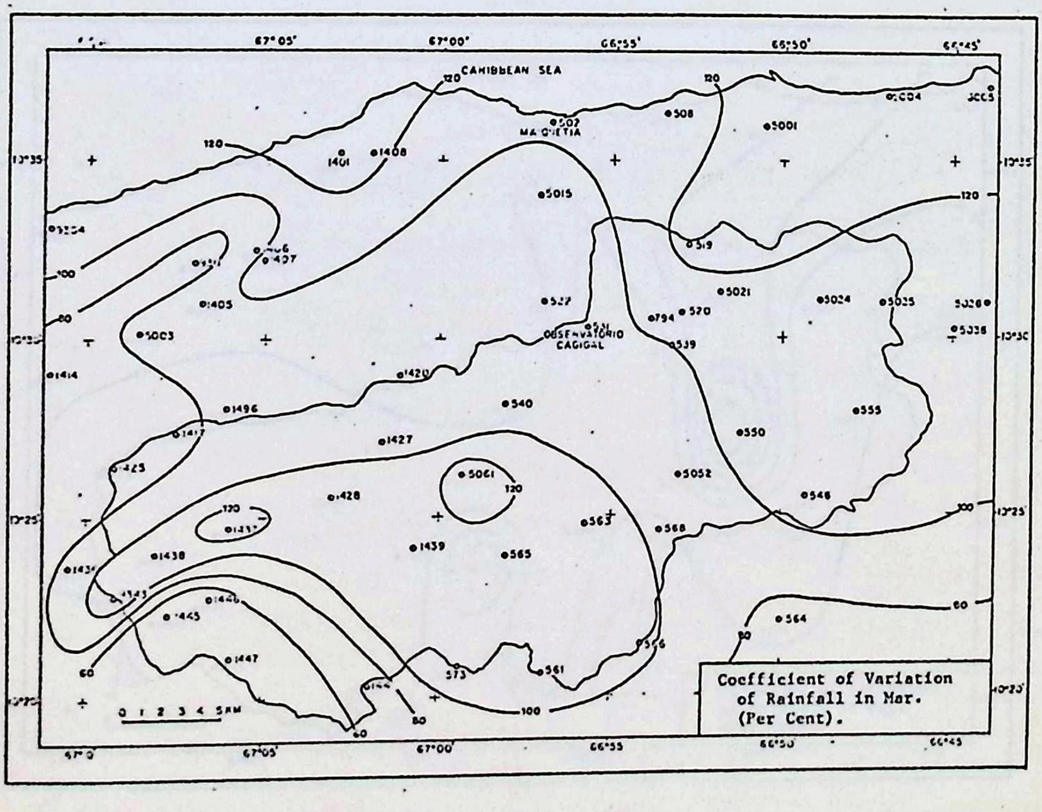
Change of Rainfall from
Oct. to Nov. Per Cent
of Annual.

APPENDIX D

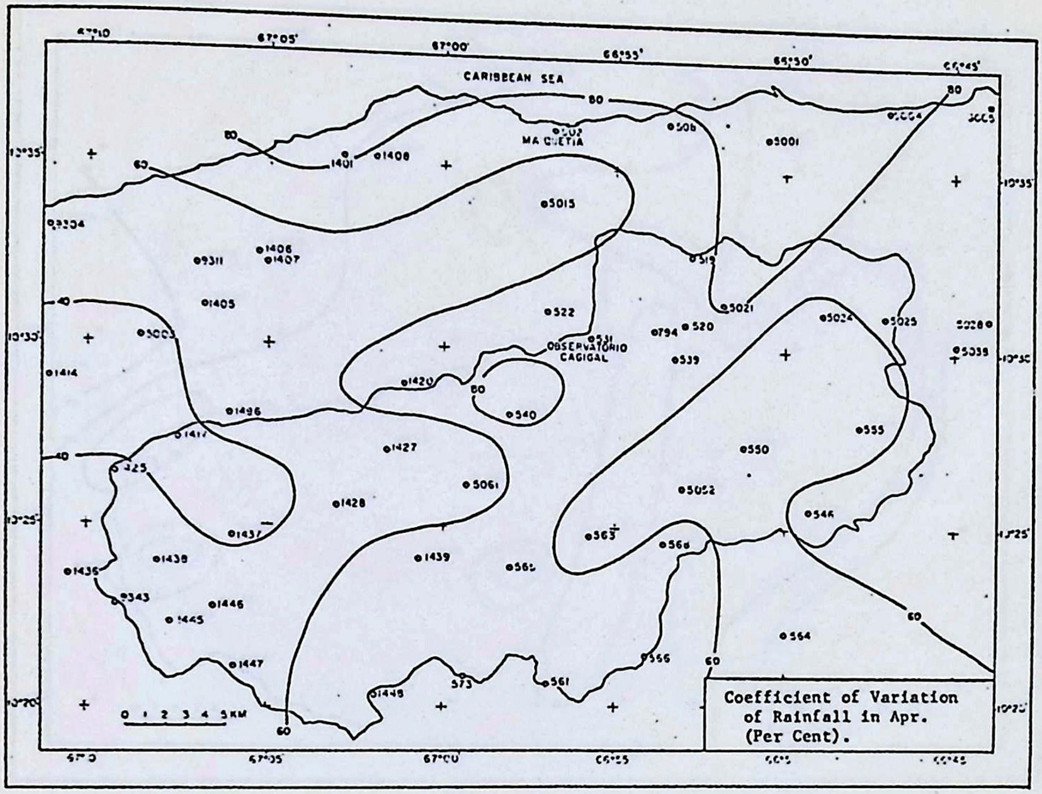
Maps showing the Coefficient of Variation of Rainfall



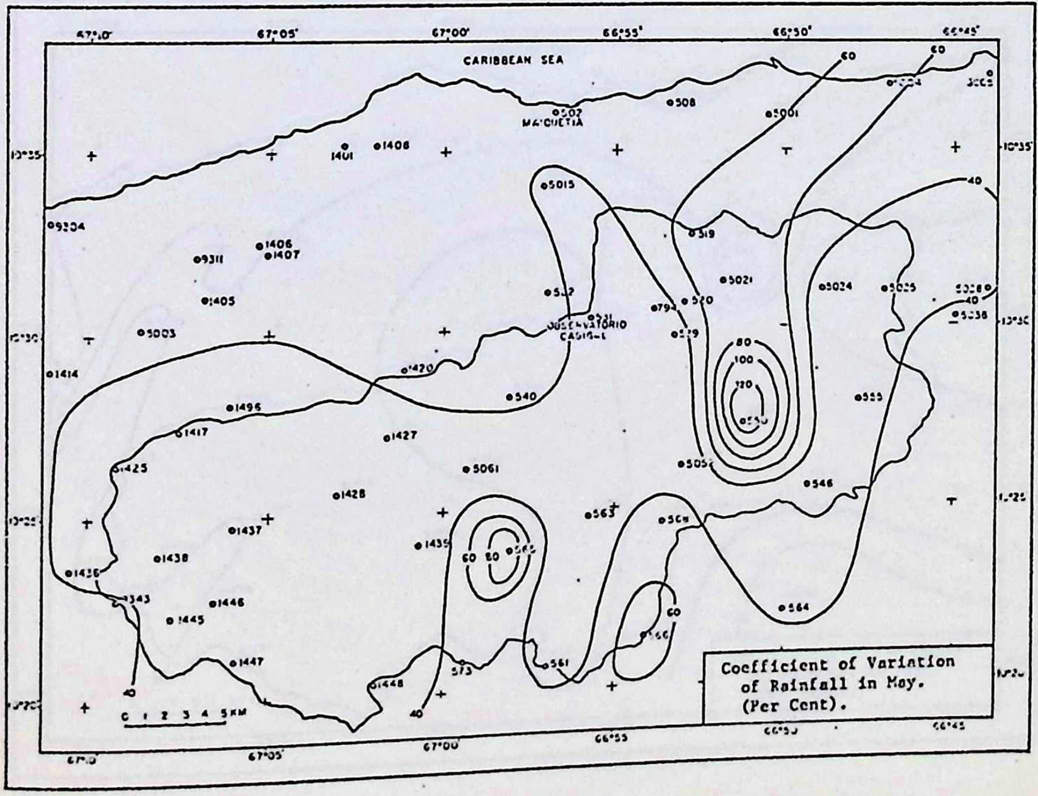
Coefficient of Variation of Rainfall in Jan. (Per Cent).



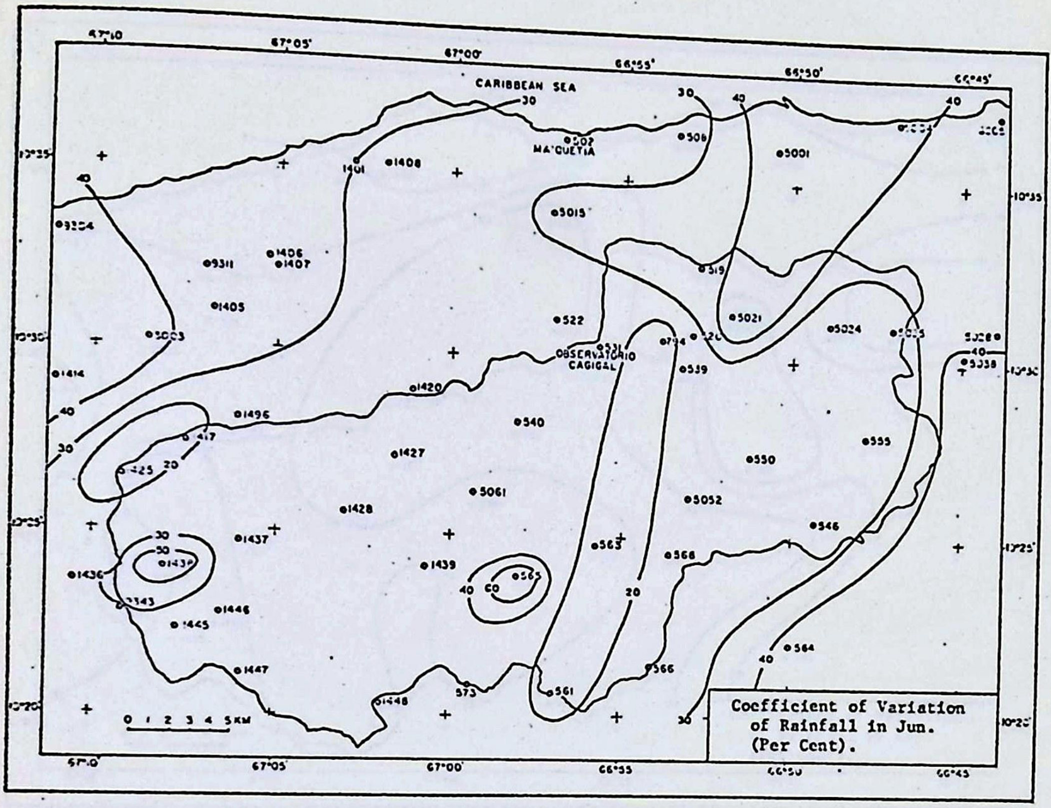
Coefficient of Variation of Rainfall in Mar. (Per Cent).



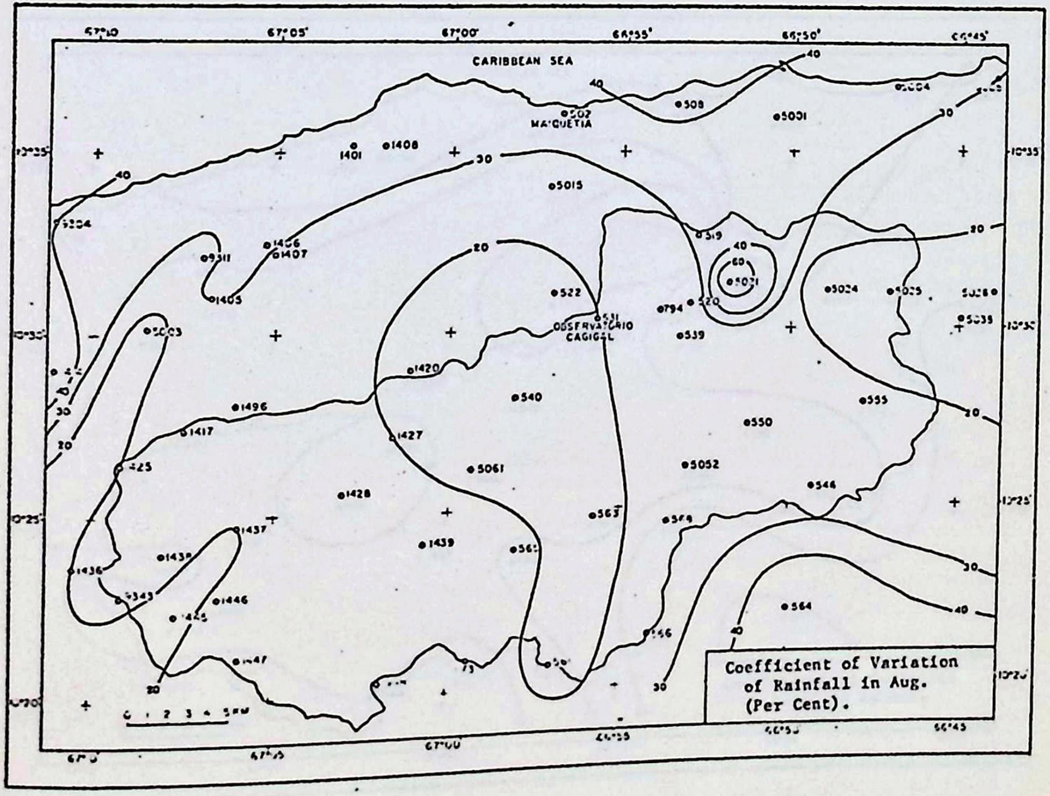
Coefficient of Variation of Rainfall in Apr. (Per Cent).



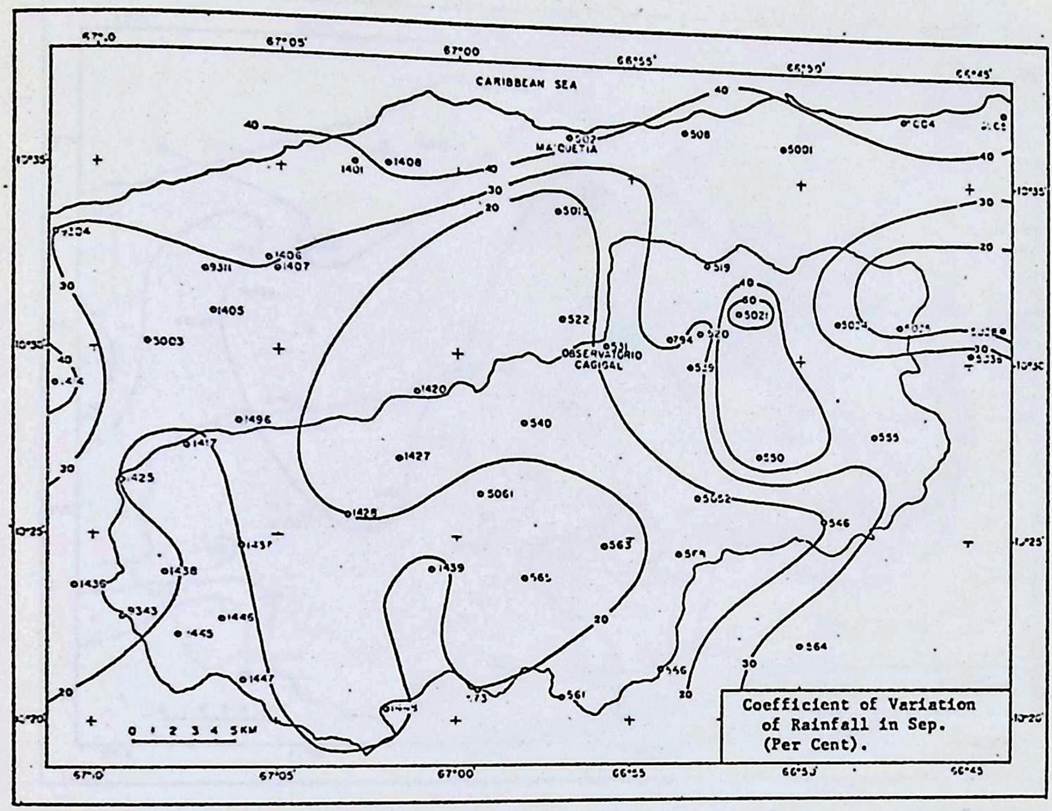
Coefficient of Variation of Rainfall in May. (Per Cent).



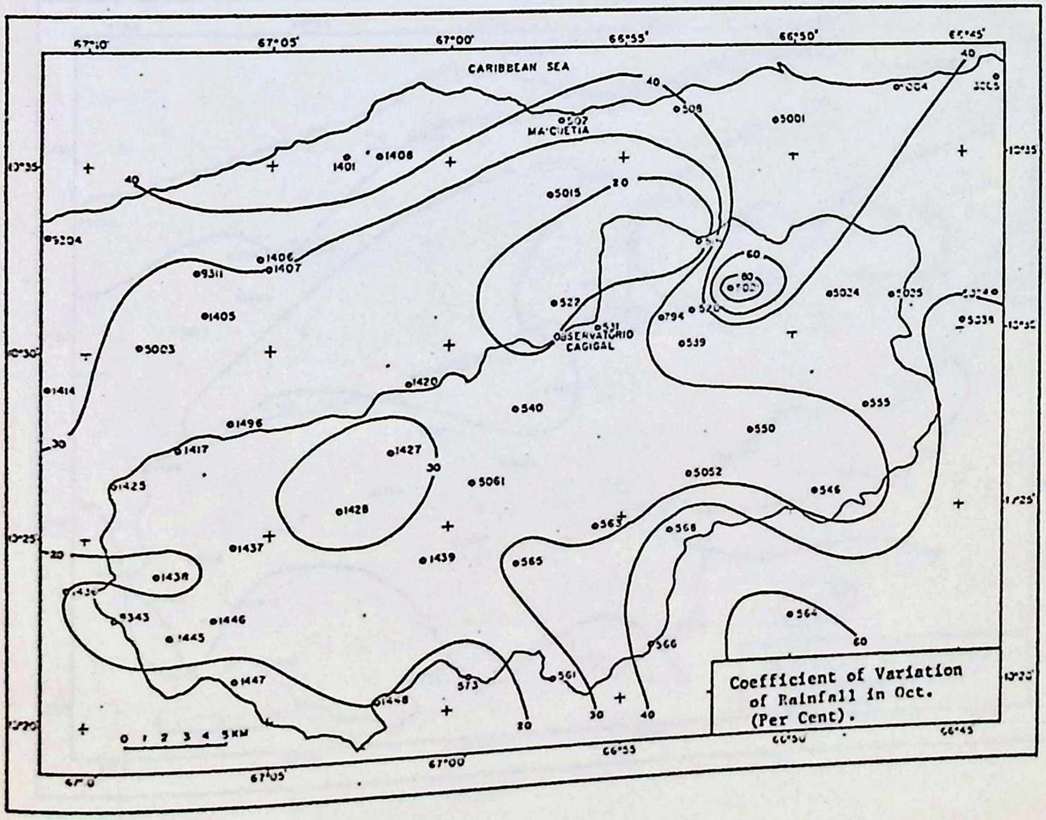
Coefficient of Variation of Rainfall in Jun. (Per Cent).



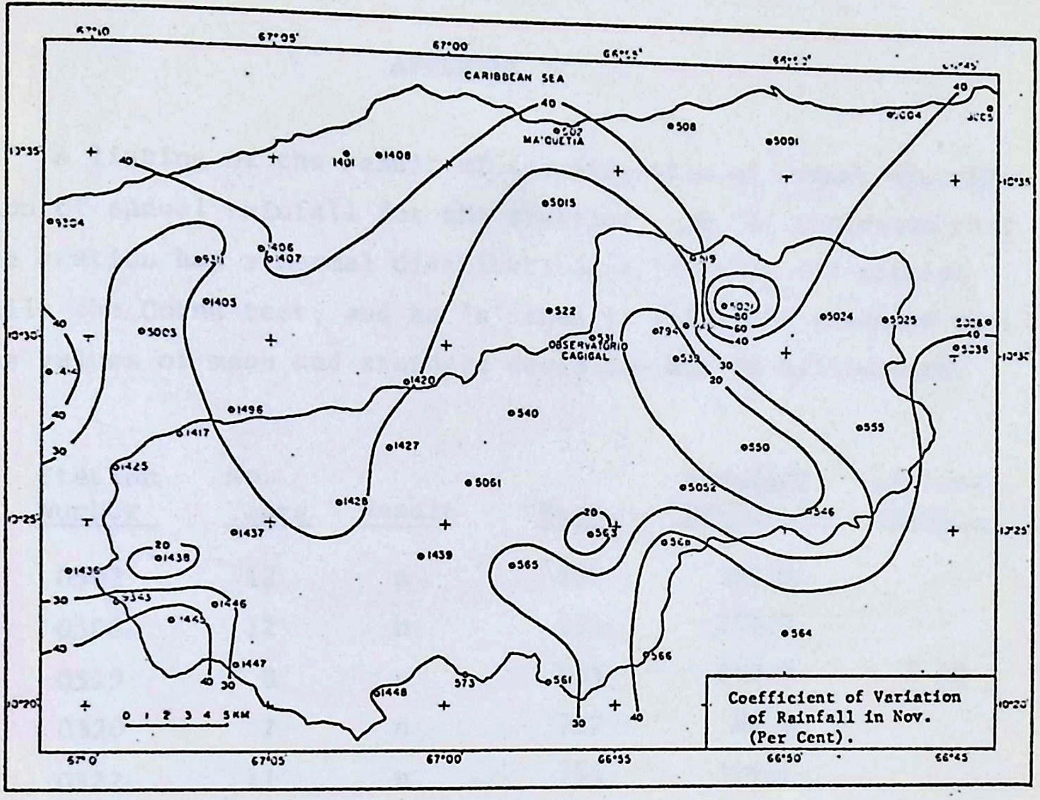
Coefficient of Variation of Rainfall in Aug. (Per Cent).



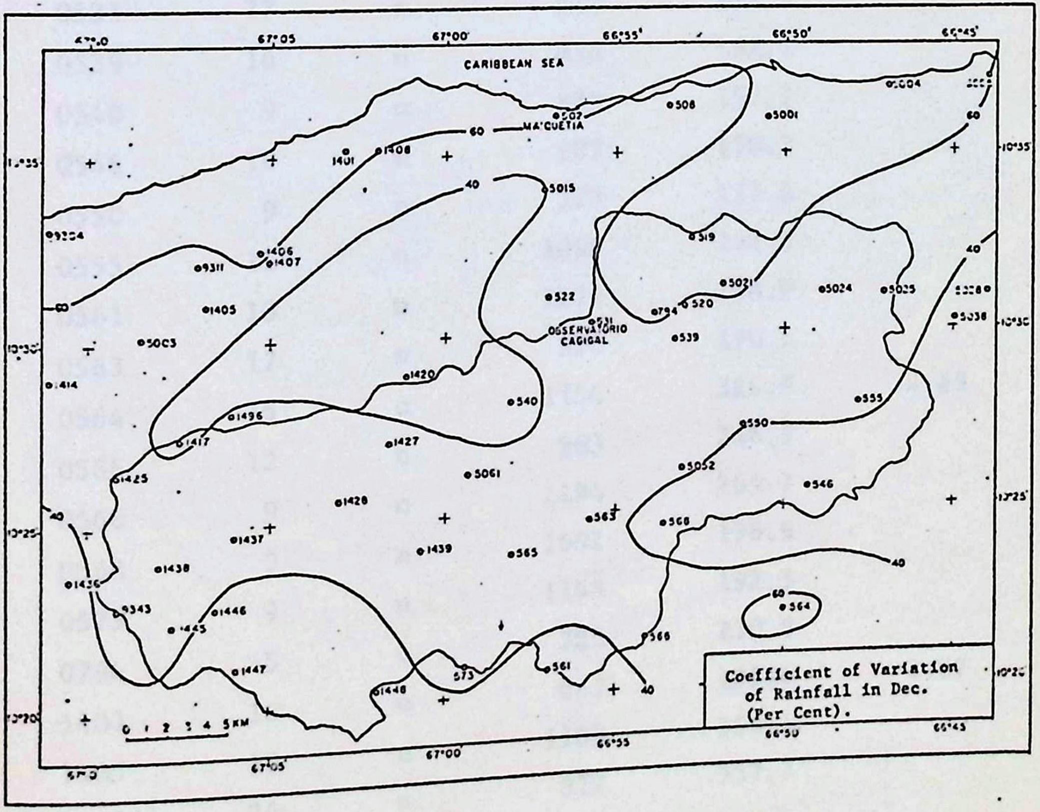
Coefficient of Variation of Rainfall in Sep. (Per Cent).



Coefficient of Variation of Rainfall in Oct. (Per Cent).



Coefficient of Variation of Rainfall in Nov. (Per Cent).



Coefficient of Variation of Rainfall in Dec. (Per Cent).

APPENDIX E

A listing of the result of investigation of normal distribution of annual rainfall for the stations. An 'n' indicates that the station has a normal distribution, a 'c' that the station fails the Cornu test, and an 's' that it fails the skewness test. The values of mean and standard deviation are in millimeters.

Station Number	No. Years	Result	Mean	Standard Deviation	Extreme Value
0502	12	n	651	163.8	
0508	12	n	593	230.9	
0519	8	c	905	213.9	2.15
0520	7	n	797	82.6	
0522	11	n	794	126.1	
0531	77	n	828	187.3	
0539	16	n	854	191.1	
0540	9	n	835	157.2	
0546	10	n	997	170.7	
0550	9	n	773	117.8	
0555	11	n	1098	191.1	
0561	13	n	1277	198.0	
0563	17	n	920	170.5	
0564	15	c	1144	325.9	2.29
0565	12	n	903	246.5	
0566	9	n	1194	269.7	
0568	9	n	1091	176.9	
0573	9	n	1163	193.5	
0794	5	n	785	130.9	
1401	10	c	427	125.6	1.67
1405	17	n	1103	350.4	
1406	24	n	822	337.7	

Station Number	No. Years	Result	Mean	Standard Deviation	Extreme Value
1407	26	s	759	300.6	2.61
1408	24	s	442	185.1	2.82
1414	7	n	1149	515.8	
1417	10	n	901	108.4	
1420	9	n	738	175.6	
1425	14	n	1085	203.0	
1427	16	c	903	182.5	2.47
1428	13	n	772	142.8	
1436	14	n	1087	160.3	
1437	13	n	859	140.1	
1438	13	n	1027	215.3	
1439	12	n	946	130.3	
1445	19	n	969	145.7	
1446	15	n	993	165.6	
1447	10	n	1115	241.6	
1448	15	n	1081	210.7	
1496	18	cs	873	626.6	3.26
5001	8	c	580	225.6	1.77
5003	12	n	849	221.0	
5004	15	n	572	253.5	
5005	10	n	646	261.1	
5015	12	n	181	205.0	
5021	18	n	754	254.5	
5024	15	c	1136	312.9	
5025	18	c	1130	251.1	2.64
5028	12	n	1309	232.1	
5038	13	n	982	178.0	
5052	11	n	889	111.2	
5061	11	n	795	170.9	
9304	15	n	652	220.4	
9311	10	n	858	206.4	
9343	12	n	1162	198.5	

APPENDIX F

Results of investigations of the square-root-normal distribution of monthly rainfall for the stations. An 'N' indicates that the station has a square-root-normal distribution. The mean and the standard deviation of the square-root values are in millimeters. The normalized extreme value when the station-month is not normal is given.

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
0502	1	17	N	5.45	4.60	
	2	18	cs	3.48	5.10	3.06
	3	16	N	2.57	2.76	
	4	17	N	4.72	3.10	
	5	18	N	6.56	3.04	
	6	17	N	8.72	2.49	
	7	19	c	8.45	2.49	2.10
	8	20	N	8.37	2.68	
	9	18	N	7.51	3.13	
	10	18	N	8.13	2.89	
	11	16	N	8.18	2.86	
	12	18	N	7.75	4.73	
0508	1	14	s	6.02	6.02	2.54
	2	16	N	2.87	3.06	
	3	16	N	2.95	3.47	
	4	15	N	4.23	3.33	
	5	16	c	5.86	2.93	2.59
	6	16	N	7.08	1.73	
	7	15	c	6.95	2.54	2.74
	8	16	N	6.87	2.91	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
0508	9	15	N	6.78	2.17	
	10	15	N	7.38	2.81	
	11	17	N	7.82	3.63	
	12	16	N	8.11	4.44	
0519	1	8	N	4.15	1.62	
	2	9	N	2.75	1.96	
	3	8	N	2.09	2.70	
	4	8	N	5.56	3.97	
	5	9	N	7.02	4.24	
	6	9	N	10.22	3.27	
	7	9	N	11.83	2.26	
	8	9	N	11.44	3.52	
	9	9	N	10.57	3.51	
	10	10	N	10.53	1.88	
	11	10	c	9.41	2.94	2.13
	12	10	N	6.07	4.14	1.48
0520	1	7	N	3.74	1.88	
	2	7	N	1.74	1.76	
	3	7	N	1.26	1.33	
	4	7	N	4.96	3.26	
	5	7	N	8.07	3.40	
	6	8	N	11.63	2.80	
	7	8	N	11.70	1.67	1.78
	8	7	N	10.60	2.40	
	9	8	c	9.90	2.28	
	10	8	N	8.10	1.80	
	11	8	N	9.13	2.54	
	12	8	N	5.07	2.91	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
0522	1	14	N	3.30	2.76	
	2	14	c	1.30	1.52	2.63
	3	13	N	2.11	1.84	
	4	13	N	1.36	2.81	
	5	12	N	8.52	3.84	
	6	12	N	9.39	2.35	
	7	14	N	10.78	1.32	
	8	14	N	10.79	1.33	
	9	15	c	10.62	1.90	2.08
	10	14	c	9.30	3.45	2.47
	11	13	N	7.62	2.23	
	12	13	N	4.94	2.61	
0531	1	77	N	3.92	2.54	
	2	77	cs	2.34	2.48	3.21
	3	77	s	2.60	2.30	3.24
	4	77	N	4.63	3.40	
	5	77	N	8.59	2.84	
	6	77	N	10.06	2.28	
	7	77	N	9.96	2.44	
	8	77	N	10.33	2.07	
	9	77	N	9.83	2.42	
	10	77	N	10.21	2.42	
	11	77	N	9.19	2.34	
	12	77	N	6.06	2.54	
0539	1	18	N	3.42	2.59	
	2	18	cs	2.59	3.27	3.41
	3	18	N	2.33	2.28	
	4	18	N	5.41	3.48	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
0539	5	18	N	8.65	2.79	
	6	18	N	11.15	2.77	
	7	19	N	10.37	1.98	
	8	19	N	10.10	2.59	
	9	19	N	9.91	2.37	
	10	18	N	9.61	3.25	
	11	18	N	8.76	1.61	
	12	19	N	8.89	2.87	
0540	1	9	N	3.14	1.56	
	2	9	N	1.72	1.42	
	3	9	N	2.52	2.22	
	4	9	N	3.93	3.30	
	5	9	N	8.88	3.89	
	6	9	N	11.36	2.53	
	7	9	N	11.64	2.07	
	8	9	N	10.26	1.97	
	9	9	N	9.63	1.57	
	10	9	N	9.92	2.66	
	11	9	N	8.61	2.19	
	12	9	N	5.18	1.68	
0546	1	11	N	4.30	2.38	
	2	11	N	3.25	1.97	
	3	11	N	2.11	2.36	
	4	11	N	4.53	2.81	
	5	10	N	8.09	3.13	
	6	11	N	14.04	3.54	
	7	12	N	13.20	2.16	
	8	12	c	11.39	2.36	2.01

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
0546	9	12	c	9.84	1.96	2.63
	10	12	c	8.85	1.92	2.53
	11	12	c	8.67	1.70	1.82
	12	12	N	6.06	2.36	
0550	1	9	N	4.18	2.51	
	2	9	N	2.34	1.63	
	3	9	N	1.83	1.99	
	4	9	N	4.72	2.30	
	5	9	N	8.08	3.62	
	6	9	N	11.70	2.98	
	7	9	c	11.31	2.35	1.93
	8	9	N	9.53	2.68	
	9	9	c	7.55	3.21	2.35
	10	9	N	8.06	1.73	
	11	9	N	9.22	1.58	
	12	9	N	5.50	2.18	
0555	1	17	N	5.19	3.03	
	2	17	N	2.82	1.78	
	3	17	N	2.81	2.96	
	4	16	N	5.89	2.58	
	5	17	N	9.44	3.60	
	6	14	N	13.32	3.21	
	7	15	N	12.67	2.22	
	8	17	N	11.57	2.40	
	9	14	cs	11.25	3.70	3.04
	10	16	N	10.64	3.27	
	11	18	cs	9.29	3.24	2.87
	12	18	N	6.70	2.76	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
0561	1	16	N	5.17	2.67	
	2	15	N	3.30	1.97	
	3	16	N	2.75	3.25	
	4	16	N	5.51	3.66	
	5	16	N	10.61	3.73	
	6	15	N	14.86	2.71	
	7	17	N	14.45	2.08	
	8	17	N	13.17	2.40	
	9	17	N	12.28	2.04	
	10	17	cs	11.80	3.33	2.87
	11	17	N	10.03	2.73	
	12	16	N	7.17	2.35	
0563	1	18	N	4.23	2.89	
	2	18	cs	2.98	2.60	3.07
	3	18	N	2.21	2.53	
	4	18	N	5.41	2.95	
	5	18	c	9.29	3.12	2.42
	6	18	N	12.32	2.24	
	7	18	N	11.43	1.59	
	8	18	N	10.85	2.07	
	9	19	N	9.90	2.38	
	10	18	N	9.67	2.11	
	11	18	N	9.19	1.87	
	12	19	N	6.22	2.61	
0564	1	15	s	5.00	4.03	2.90
	2	15	c	4.11	2.76	1.75
	3	15	N	4.48	3.26	
	4	15	N	8.07	3.88	
	5	15	N	9.97	3.63	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
0564	6	15	N	9.83	4.04	
	7	15	cs	10.58	3.62	2.92
	8	15	c	11.69	4.68	2.50
	9	15	cs	10.92	4.70	2.32
	10	15	N	10.22	6.22	
	11	15	N	9.73	5.48	
	12	15	N	6.77	4.11	
0565	1	12	N	3.68	3.03	
	2	12	N	3.22	2.47	
	3	12	N	2.33	2.44	
	4	12	N	4.51	3.04	
	5	12	N	5.57	4.53	
	6	12	N	9.75	6.18	
	7	12	N	12.90	1.87	
	8	12	N	10.53	4.07	
	9	12	cs	9.00	3.36	2.67
	10	12	c	10.21	3.76	2.71
	11	12	cs	8.84	3.30	2.67
	12	12	N	6.62	3.02	
0566	1	9	N	5.64	3.47	
	2	9	N	3.84	2.38	
	3	9	c	2.62	2.82	2.45
	4	9	N	3.95	3.10	
	5	9	N	6.51	4.77	
	6	9	N	15.07	3.68	
	7	9	N	13.67	2.18	
	8	9	N	12.34	2.97	
	9	9	c	12.91	1.74	2.10

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
0566	10	9	c	9.64	3.95	2.44
	11	9	c	9.11	3.68	2.47
	12	9	N	7.33	4.09	
0568	1	9	N	4.82	1.60	
	2	9	c	3.45	2.33	2.47
	3	9	N	3.00	2.85	
	4	9	N	5.49	3.41	
	5	9	N	9.72	4.57	
	6	9	N	14.35	3.01	
	7	9	N	13.37	2.43	
	8	9	N	12.14	3.08	
	9	9	N	11.02	1.63	
	10	9	N	8.41	3.64	
	11	9	c	7.81	3.37	2.31
	12	9	N	6.65	1.66	
0573	1	9	N	4.11	2.17	
	2	9	N	2.40	1.66	
	3	9	N	2.65	3.15	
	4	9	N	4.31	2.92	
	5	9	c	9.93	4.17	3.17
	6	9	N	13.85	2.99	
	7	9	N	13.94	2.19	
	8	9	N	12.06	3.15	
	9	9	N	11.74	2.38	
	10	9	N	11.82	1.93	
	11	9	N	9.41	2.73	
	12	9	N	6.10	2.58	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
0794	1	6	N	3.47	2.38	
	2	6	N	1.91	2.23	
	3	6	N	1.63	1.78	
	4	6	N	4.78	3.79	
	5	6	c	8.44	3.27	1.80
	6	6	c	11.00	1.88	1.94
	7	6	c	8.85	4.82	1.83
	8	N	N	10.15	2.62	
	9	6	N	8.92	2.97	
	10	6	c	9.77	2.94	1.76
	11	5	N	8.90	1.73	
	12	6	N	3.93	2.68	
1401	1	11	cs	3.29	3.75	2.72
	2	12	N	1.63	2.02	
	3	12	N	2.00	2.99	
	4	12	N	3.47	3.03	
	5	12	N	5.57	3.09	
	6	12	N	6.77	2.04	
	7	12	N	7.52	1.75	
	8	11	N	6.77	1.27	
	9	10	N	5.41	1.27	
	10	12	N	5.55	2.96	
	11	12	N	6.14	3.28	
	12	12	N	6.34	3.82	
1405	1	24	s	6.28	5.37	2.69
	2	23	N	3.71	3.03	
	3	25	N	4.26	3.92	
	4	24	N	7.12	2.92	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
1405	5	24	c	9.18	3.74	2.45
	6	26	N	9.03	2.96	
	7	25	cs	9.65	3.44	3.31
	8	25	N	11.33	3.41	
	9	24	N	10.61	2.65	
	10	25	N	12.02	2.48	
	11	24	N	12.08	4.39	
	12	24	N	7.04	3.88	
1406	1	26	N	5.62	4.38	
	2	26	cs	3.52	4.07	3.46
	3	26	N	3.75	3.46	
	4	26	N	5.70	3.17	
	5	26	N	8.19	3.74	
	6	26	N	7.58	2.68	
	7	27	N	7.97	2.28	
	8	27	c	9.83	3.86	2.86
	9	25	cs	9.53	3.10	
	10	27	N	10.48	3.53	3.07
	11	27	N	10.50	4.11	
	12	27	N	6.06	3.77	
1407	1	26	s	4.46	4.07	3.04
	2	26	cs	2.92	4.27	3.27
	3	27	s	2.75	2.97	2.56
	4	27	c	4.63	2.36	2.64
	5	27	N	7.93	3.28	
	6	27	N	7.82	2.61	
	7	27	N	8.28	2.81	
	8	27	N	9.28	2.64	
	9	27	c	9.53	2.38	2.69

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
1407	10	27	N	9.85	3.00	
	11	27	N	9.41	4.03	
	12	27	N	5.93	2.97	
1408	1	27	N	4.04	3.53	3.64
	2	27	s	3.05	3.87	
	3	26	s	2.05	2.58	2.44
	4	26	N	3.05	2.42	
	5	26	N	6.21	3.29	
	6	25	N	5.98	1.74	
	7	26	N	6.10	1.71	
	8	26	s	6.99	2.59	2.84
	9	27	cs	5.49	2.20	3.60
	10	27	N	5.94	2.56	
	11	27	N	6.59	3.66	
	12	27	c	5.73	3.47	2.54
1414	1	12	N	6.94	5.74	
	2	13	N	4.63	2.68	
	3	13	cs	4.09	2.56	2.69
	4	16	N	9.17	3.19	
	5	17	N	9.26	4.50	
	6	15	N	8.38	3.77	
	7	12	N	9.46	4.25	
	8	15	N	10.23	5.23	
	9	15	N	9.91	3.97	
	10	16	N	11.34	3.86	
	11	14	N	10.59	4.32	
	12	15	N	7.26	4.19	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
1417	1	15	c	5.88	3.76	2.40
	2	19	s	4.36	2.84	3.05
	3	18	N	3.91	2.60	
	4	19	N	6.91	2.20	
	5	18	c	8.75	2.32	2.16
	6	19	N	10.66	1.45	
	7	17	N	10.59	2.40	
	8	18	N	9.93	2.04	
	9	18	N	9.71	1.86	
	10	16	N	10.53	1.82	
	11	16	N	9.47	2.11	
	12	17	N	7.07	2.74	
1420	1	9	c	3.45	2.34	2.42
	2	9	N	2.56	1.75	
	3	9	N	2.83	2.33	
	4	9	N	4.92	3.46	
	5	9	N	6.34	3.31	
	6	9	N	10.51	2.48	
	7	9	N	10.41	1.96	
	8	9	N	10.06	1.53	
	9	9	N	8.53	1.44	
	10	9	N	8.96	2.26	
	11	9	N	8.25	2.60	
	12	9	N	6.52	2.39	
1425	1	15	cs	5.75	3.30	2.76
	2	16	N	4.77	2.51	
	3	17	N	4.26	2.85	
	4	17	N	7.57	3.43	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
1425	5	17	N	10.00	3.34	
	6	17	N	11.74	2.23	
	7	17	N	11.32	2.60	
	8	18	N	10.34	2.03	
	9	19	N	10.41	2.09	
	10	19	N	10.91	2.84	
	11	19	N	9.75	2.05	
	12	19	N	7.61	3.67	
1427	1	16	N	5.50	3.46	
	2	16	N	3.25	1.88	
	3	18	N	3.08	2.63	
	4	18	N	6.00	2.44	
	5	18	c	9.28	3.29	2.11
	6	18	N	11.90	2.71	
	7	18	N	10.93	1.85	
	8	18	N	10.18	2.04	
	9	19	N	9.39	1.69	
	10	19	c	9.70	3.39	2.86
	11	19	N	8.34	1.86	
	12	19	N	6.79	2.81	
1428	1	17	N	4.18	2.96	
	2	16	N	2.00	1.89	
	3	17	N	1.84	2.11	
	4	16	N	6.09	2.76	
	5	16	N	8.67	3.16	
	6.	18	N	10.85	2.66	
	7	18	N	10.54	1.97	
	8	17	N	9.27	2.53	
	9	17	N	9.49	1.90	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
1428	10	18	c	9.30	3.43	2.71
	11	17	cs	7.26	2.37	3.06
	12	18	c	4.90	2.88	2.85
1436	1	18	N	5.11	2.68	
	2	18	cs	3.98	2.31	3.26
	3	17	N	3.09	2.54	
	4	16	N	6.42	3.16	
	5	16	N	9.73	3.18	
	6	19	N	13.03	2.83	
	7	19	N	2.11	2.36	
	8	19	N	11.34	2.21	
	9	18	N	11.21	2.41	
	10	18	N	10.65	2.12	
	11	19	N	8.91	2.10	
	12	17	N	6.53	2.26	
1437	1	17	N	5.01	2.42	
	2	18	cs	2.72	2.31	3.03
	3	16	s	2.21	2.64	2.54
	4	16	N	6.21	2.36	
	5	17	c	8.85	2.89	2.68
	6	17	N	11.11	2.51	
	7	18	N	10.26	2.73	
	8	18	N	9.39	1.91	
	9	17	N	9.53	1.89	
	10	19	N	10.26	2.50	
	11	18	N	8.45	2.40	
	12	16	N	6.17	2.79	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
1438	1	13	N	5.81	2.60	
	2	13	N	3.60	1.26	
	3	13	N	3.47	3.69	
	4	13	c	5.42	2.90	2.36
	5	13	N	10.02	3.60	
	6	13	c	10.91	5.53	1.97
	7	13	cs	11.68	4.19	2.78
	8	13	N	9.74	3.67	
	9	13	cs	10.29	3.50	2.94
	10	13	N	10.24	1.95	
	11	13	c	10.10	2.02	1.83
	12	13	N	6.58	3.50	
1439	1	19	N	4.18	2.79	
	2	17	N	2.66	1.89	
	3	17	N	1.67	1.95	
	4	16	N	4.75	3.57	
	5	17	N	8.46	3.05	
	6	19	N	12.06	2.62	
	7	19	N	11.22	2.40	
	8	19	N	10.58	2.46	
	9	17	N	10.65	1.65	
	10	19	N	10.96	2.95	
	11	19	N	9.19	1.89	
	12	18	N	5.86	2.62	
1445	1	19	c	4.92	3.15	1.56
	2	19	cs	3.97	3.49	3.45
	3	19	N	3.39	3.04	
	4	19	N	6.54	2.81	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
1445	5	19	N	9.47	3.37	
	6	19	N	12.46	2.71	
	7	19	N	11.27	2.73	
	8	19	N	10.59	2.06	
	9	19	N	9.45	1.56	
	10	19	N	10.46	2.25	
	11	19	N	7.91	3.54	
	12	19	N	5.91	2.87	
1446	1	19	N	5.37	3.16	
	2	19	cs	3.79	2.74	3.18
	3	18	N	2.94	2.88	
	4	19	N	5.53	2.80	
	5	19	N	9.85	3.39	
	6	18	N	13.07	2.98	
	7	18	N	11.86	2.95	
	8	18	N	11.10	1.85	
	9	17	N	10.02	1.54	
	10	19	cs	11.19	2.57	
	11	18	N	9.47	3.00	
	12	19	N	6.87	2.37	
1447	1	17	N	4.53	2.61	
	2	17	N	3.07	1.79	
	3	19	s	2.91	2.89	2.87
	4	19	N	5.06	2.79	
	5	17	N	9.33	2.99	
	6	17	N	13.93	3.52	
	7	18	N	12.75	2.79	
	8	17	cs	10.73	3.40	3.15

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
1447	9	15	c	11.24	2.17	2.78
	10	15	N	10.48	2.17	
	11	18	N	8.91	2.56	
	12	19	N	6.17	2.38	
1448	1	15	N	4.34	2.45	
	2	15	N	2.53	1.97	
	3	17	N	2.48	2.50	
	4	17	N	5.10	3.47	
	5	17	N	9.55	2.80	
	6	19	N	13.79	3.60	
	7	19	N	12.38	2.76	
	8	17	N	11.62	2.60	
	9	19	c	11.53	2.98	2.19
	10	18	c	11.77	2.36	2.41
	11	18	c	8.87	2.37	2.34
	12	17	N	6.26	2.47	
1496	1	26	N	5.14	3.08	
	2	25	cs	4.06	3.71	3.65
	3	24	N	3.92	3.30	
	4	22	N	6.05	3.20	
	5	26	N	8.30	2.82	
	6	25	N	7.76	2.00	
	7	25	N	7.77	1.92	
	8	26	N	9.62	2.47	
	9	25	N	9.60	2.07	
	10	25	N	10.97	2.49	
	11	22	s	10.41	3.36	2.31
	12	25	N	6.43	2.71	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
5001	1	9	cs	4.43	4.75	2.56
	2	9	N	3.26	3.26	3.23
	3	9	N	3.17	4.11	
	4	9	N	4.55	3.86	
	5	9	N	5.91	3.36	
	6	9	N	5.91	3.36	
	7	9	N	7.88	2.19	
	8	10	N	6.18	1.93	
	9	10	N	6.38	2.15	
	10	10	N	6.76	3.61	
	11	10	N	5.75	3.94	
	12	10	N	7.96	4.94	
5003	1	12	cs	3.80	3.78	2.67
	2	12	N	2.37	2.12	
	3	12	c	2.22	1.98	2.52
	4	12	c	7.93	3.64	2.17
	5	12	N	7.33	4.32	
	6	12	N	7.79	3.44	
	7	12	N	9.14	2.10	
	8	12	c	11.58	2.21	2.13
	9	12	N	9.97	2.53	
	10	12	N	9.87	2.56	
	11	12	c	8.65	3.53	2.45
	12	12	N	6.67	4.58	
5004	1	15	s	5.34	4.91	2.72
	2	15	N	3.23	3.36	
	3	15	s	2.65	3.59	2.56
	4	15	N	4.14	3.87	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
5004	5	15	N	5.46	3.40	
	6	15	N	6.93	3.07	
	7	15	c	8.22	2.38	2.18
	8	15	N	6.39	2.27	
	9	15	N	6.36	2.62	
	10	15	N	6.44	3.20	
	11	15	N	6.97	4.64	
	12	15	N	6.84	4.64	
5005	1	15	N	6.80	5.80	
	2	14	N	2.37	2.82	
	3	13	N	3.39	4.26	
	4	16	N	4.57	3.15	
	5	15	N	5.15	2.43	
	6	16	N	7.20	2.68	
	7	17	N	7.64	2.48	
	8	15	N	6.21	1.83	
	9	15	N	5.92	2.80	
	10	16	N	6.73	2.61	
	11	16	N	8.50	4.16	
	12	16	c	10.12	6.02	2.28
5015	1	16	N	7.03	5.66	
	2	16	s	3.65	2.10	2.90
	3	16	cs	4.24	3.03	3.12
	4	15	N	6.60	2.59	
	5	15	N	7.47	2.61	
	6	15	N	10.29	3.19	
	7	16	N	11.55	3.28	
	8	17	N	10.92	2.80	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
5015	9	17	N	10.97	1.73	
	10	17	N	11.19	2.61	
	11	16	N	10.21	3.13	
	12	16	N	9.27	3.68	
5021	1	18	N	3.24	3.00	
	2	18	cs	2.84	4.32	3.54
	3	18	N	2.00	2.21	
	4	18	N	4.60	3.89	
	5	18	N	7.59	4.91	
	6	18	N	10.13	5.60	
	7	18	N	7.23	5.43	
	8	18	N	7.41	5.84	
	9	18	N	7.61	5.93	
	10	18	N	6.72	5.59	
	11	18	N	8.12	4.61	
	12	18	N	4.83	3.13	
5024	1	18	N	5.37	4.17	
	2	17	cs	4.30	5.06	3.31
	3	18	N	2.45	2.91	
	4	18	N	5.63	3.15	
	5	18	N	9.28	3.27	
	6	18	N	12.95	3.63	
	7	17	N	12.28	2.57	
	8	18	N	12.24	1.82	
	9	19	N	11.49	2.71	
	10	19	N	11.19	3.94	
	11	19	N	10.00	2.66	
	12	19	N	7.12	2.90	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
5025	1	19	N	5.03	4.18	
	2	18	cs	3.79	3.85	3.20
	3	18	N	3.12	3.36	
	4	19	N	4.84	3.21	
	5	19	c	9.91	3.75	2.58
	6	19	N	12.51	4.52	
	7	19	N	12.08	2.55	
	8	19	N	11.79	1.58	
	9	19	N	11.73	1.51	
	10	19	N	11.50	3.61	
	11	19	N	8.56	3.80	
	12	19	N	6.93	3.08	
5028	1	18	N	8.05	5.48	
	2	16	N	4.16	3.40	
	3	17	N	3.74	3.81	
	4	18	N	6.02	3.95	
	5	17	N	9.84	3.76	
	6	17	cs	13.34	4.65	2.86
	7	16	c	12.74	4.53	2.81
	8	18	N	12.25	2.23	
	9	18	N	12.39	2.05	
	10	18	c	12.45	4.25	2.04
	11	19	N	11.38	2.66	
	12	18	N	9.36	3.48	
5038	1	13	N	4.07	2.55	
	2	13	N	2.50	1.71	
	3	13	N	3.18	3.25	
	4	13	N	4.78	3.14	
	5	13	N	7.88	4.03	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
5038	6	13	N	12.36	5.09	
	7	13	N	12.65	2.68	
	8	13	N	10.85	2.58	
	9	13	c	10.19	3.64	2.79
	10	13	N	9.38	4.89	
	11	13	N	8.02	3.42	
	12	13	N	6.76	2.58	
5052	1	14	N	4.09	2.56	
	2	15	cs	2.57	1.48	2.84
	3	14	N	1.93	1.87	
	4	16	N	5.59	2.95	
	5	16	N	8.82	2.92	
	6	15	N	12.40	2.59	
	7	13	N	11.83	2.08	
	8	16	c	10.45	2.41	2.67
	9	15	N	9.29	1.80	
	10	16	c	9.62	2.53	1.97
	11	16	N	8.25	2.68	
	12	16	N	6.04	2.56	
5061	1	13	N	4.02	2.38	
	2	13	N	2.36	1.50	
	3	14	N	1.91	2.33	
	4	15	N	5.20	2.97	
	5	15	c	8.41	2.77	2.31
	6	15	N	10.87	2.69	
	7	15	N	10.75	1.78	
	8	15	N	9.55	1.84	
	9	14	N	9.89	2.15	
	10	15	c	9.34	2.65	2.08

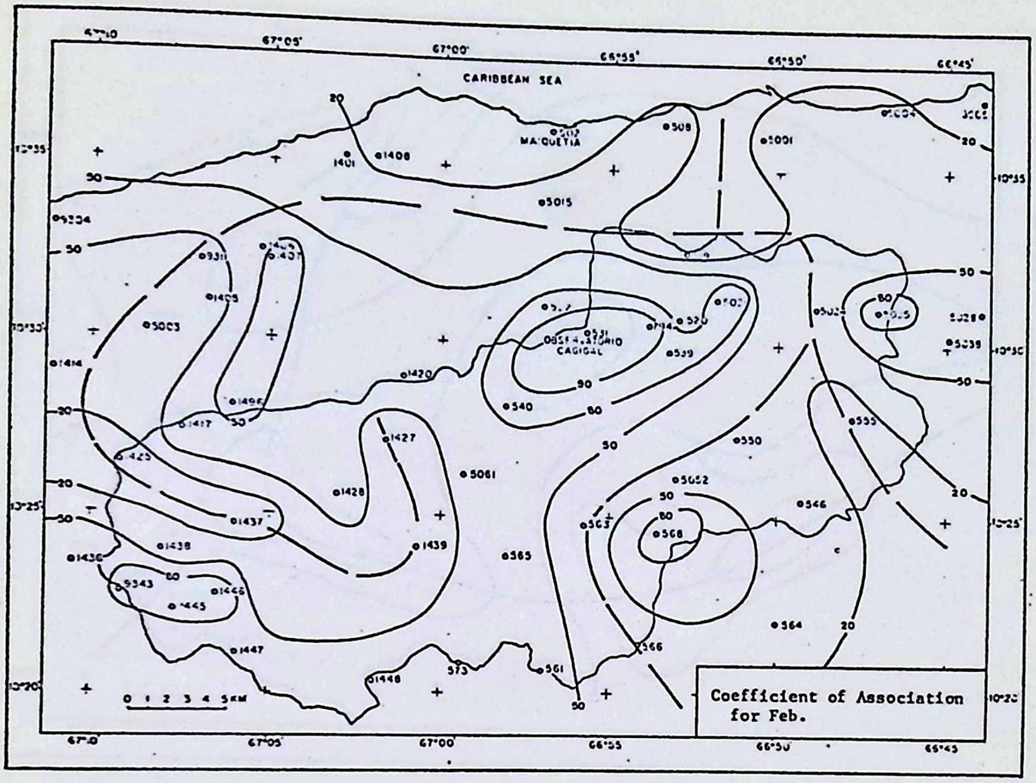
Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
5061	11	15	N	8.02	1.41	
	12	15	N	5.57	2.67	
9304	1	16	N	4.65	4.31	
	2	17	cs	3.01	4.92	3.50
	3	17	N	2.80	3.16	
	4	17	c	4.05	2.29	2.63
	5	17	N	7.55	2.17	
	6	17	N	5.99	2.45	
	7	17	N	7.41	1.86	
	8	17	N	8.01	3.22	
	9	17	N	7.88	2.40	
	10	16	N	8.28	2.91	
	11	17	N	8.48	3.44	
	12	17	N	6.74	4.22	
9311	1	11	cs	4.45	4.44	2.77
	2	12	N	2.68	1.97	
	3	12	N	2.31	1.64	
	4	11	c	6.92	3.07	2.25
	5	12	N	7.87	4.49	
	6	12	N	8.56	2.26	
	7	11	c	9.32	3.38	2.57
	8	11	c	10.53	2.80	2.50
	9	12	N	9.14	2.33	
	10	11	N	10.87	2.76	
	11	11	N	8.97	3.04	
	12	12	N	7.46	3.64	

Station Number	Month	No. Years	Results	Mean of Sq. Root	Standard Deviation of Sq. Root	Extreme Value
9343	1	19	N	3.79	3.09	
	2	19	cs	2.80	3.22	3.52
	3	19	s	2.66	2.85	2.65
	4	19	N	6.20	3.12	
	5	18	N	9.95	4.02	
	6	18	N	12.37	3.74	
	7	17	N	12.25	2.94	
	8	17	N	12.37	2.68	
	9	18	N	11.08	2.63	
	10	17	N	10.69	3.28	
	11	17	N	9.42	3.56	
	12	18	N	5.69	2.38	

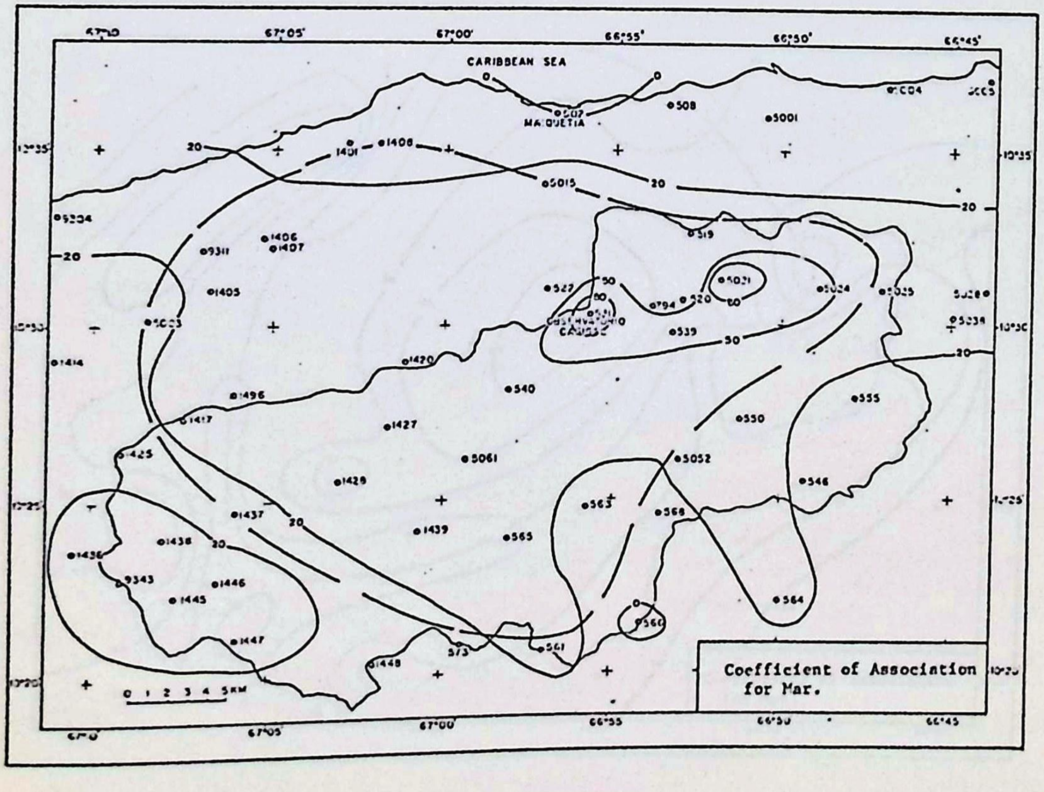
APPENDIX G

Maps showing the Coefficient of Association for Monthly and Annual Rainfall as computed against 'Observatorio Cagigal'

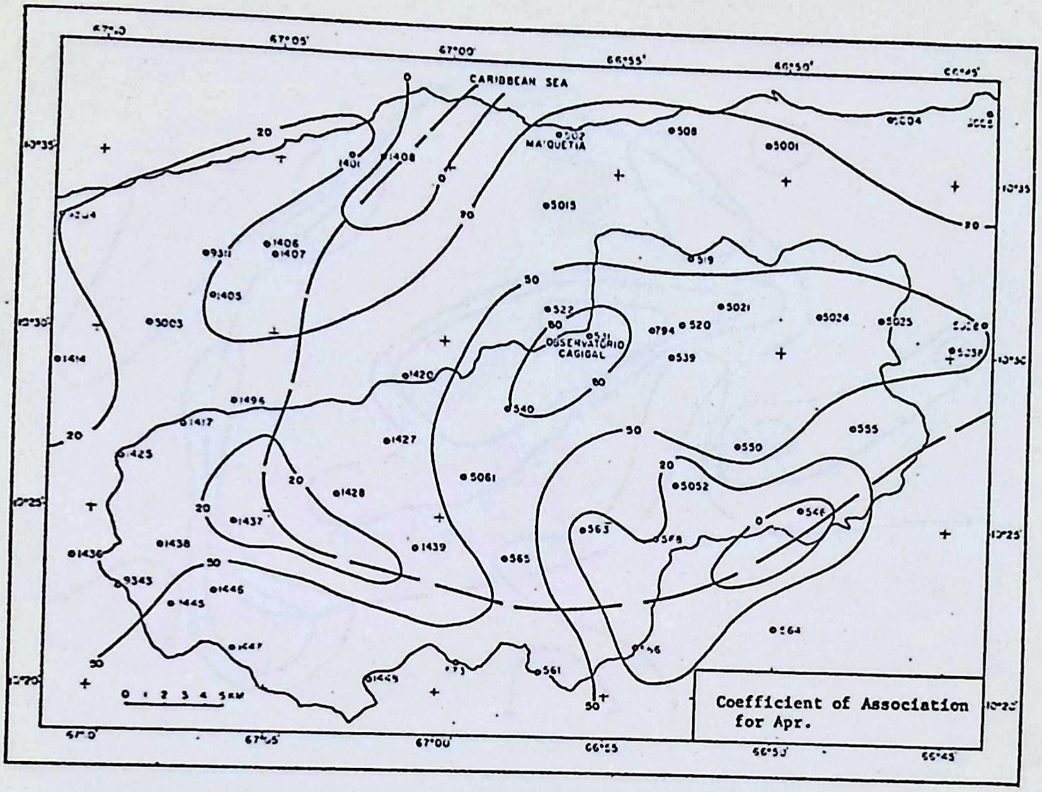
—— —— —— Indicates Line of Low Value



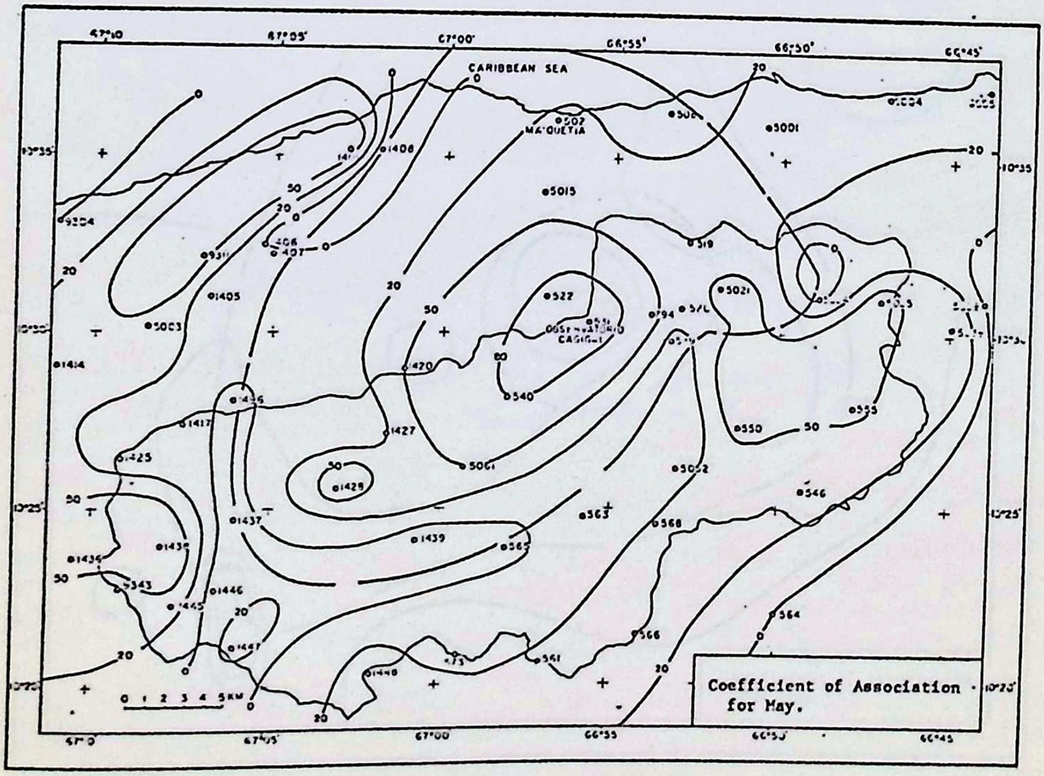
Coefficient of Association for Feb.



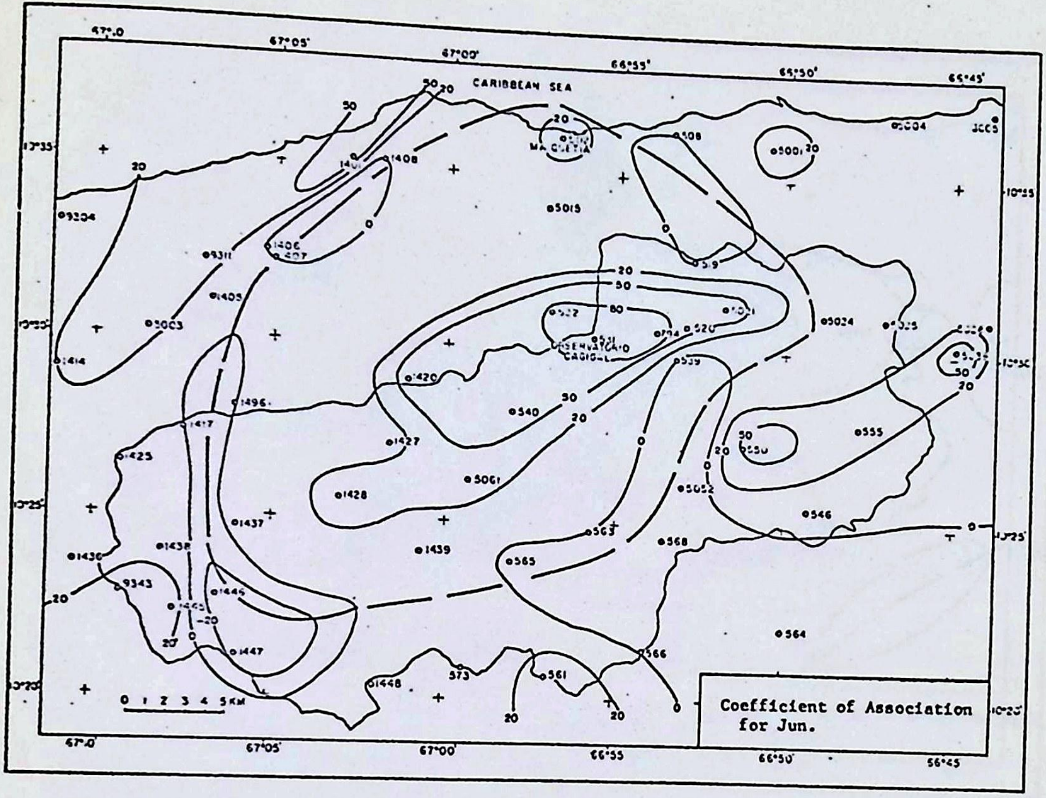
Coefficient of Association for Mar.



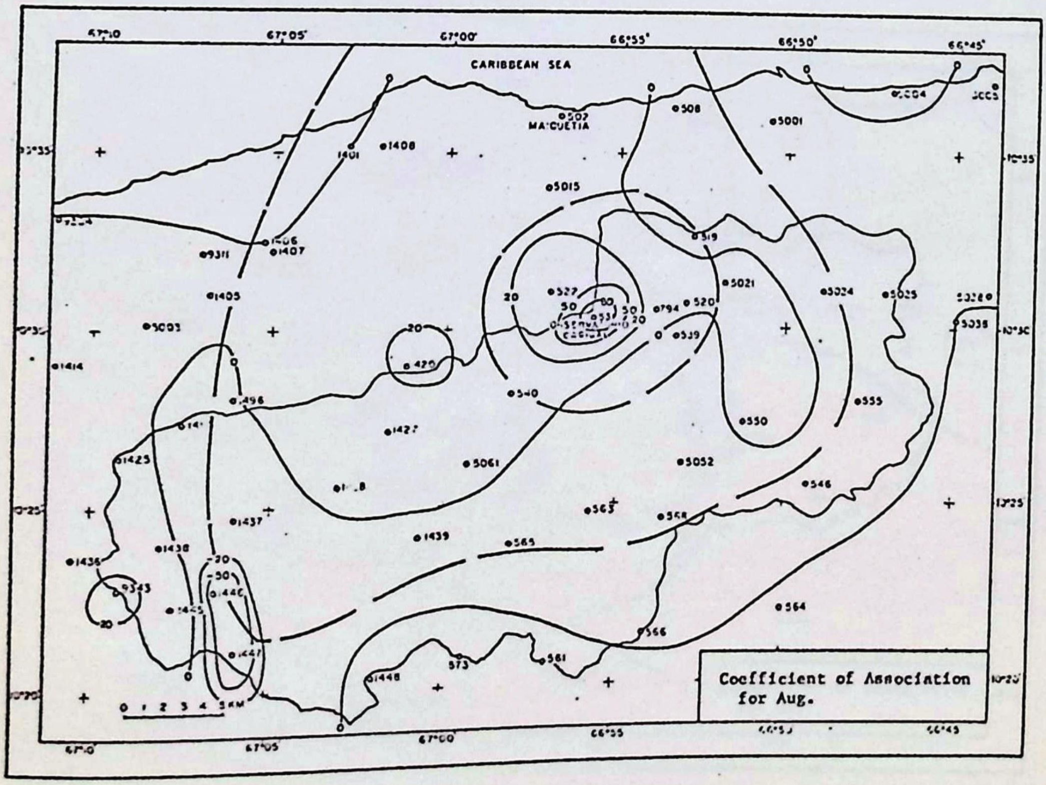
Coefficient of Association for Apr.



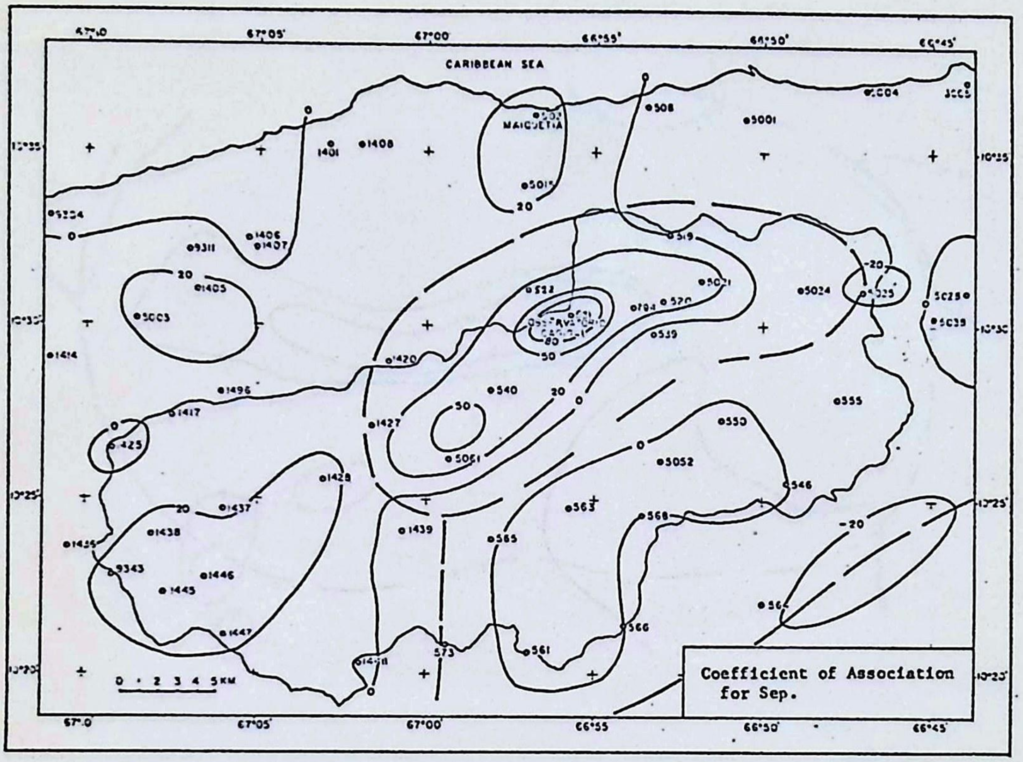
Coefficient of Association for May.



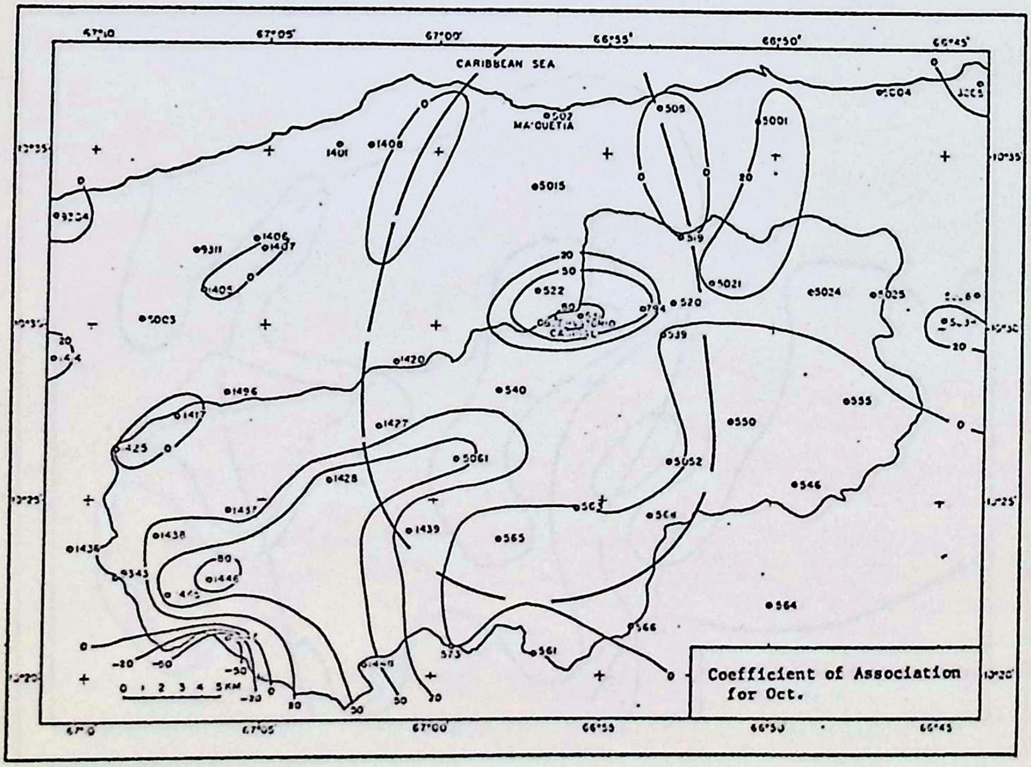
Coefficient of Association for Jun.



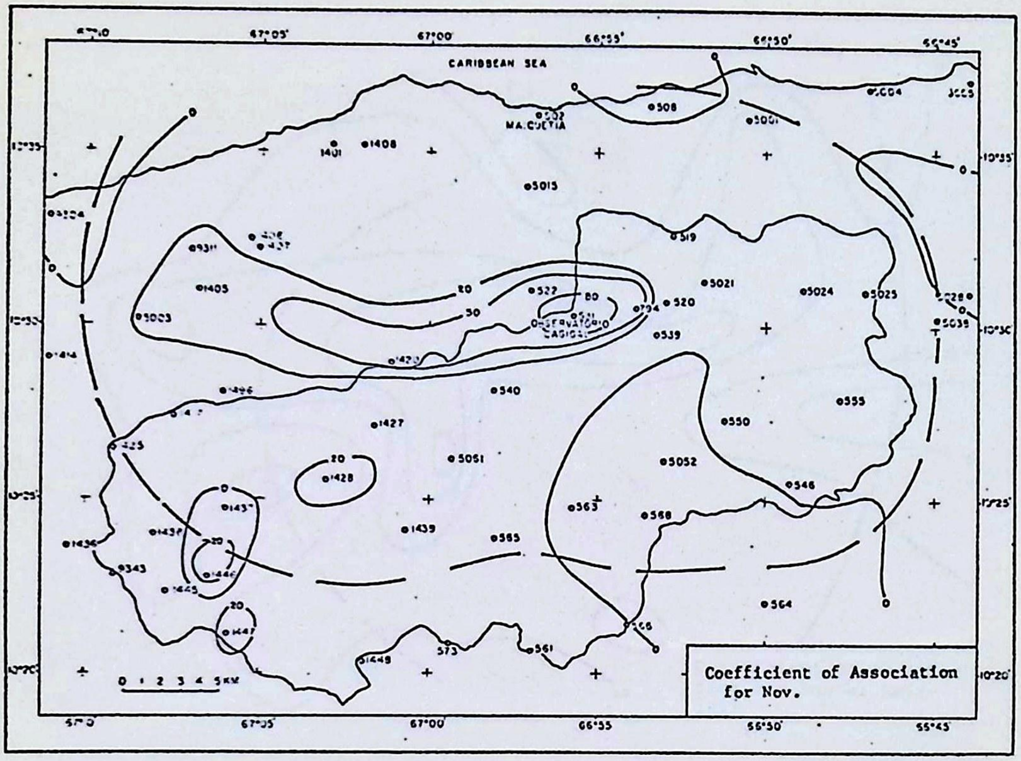
Coefficient of Association for Aug.



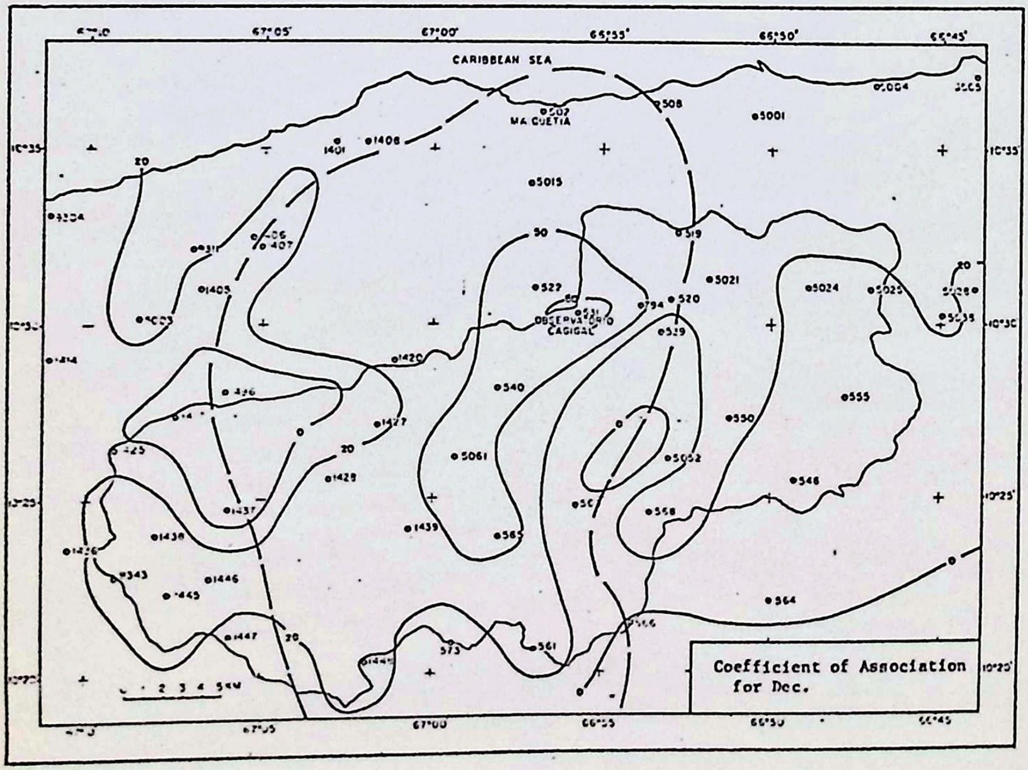
Coefficient of Association for Sep.



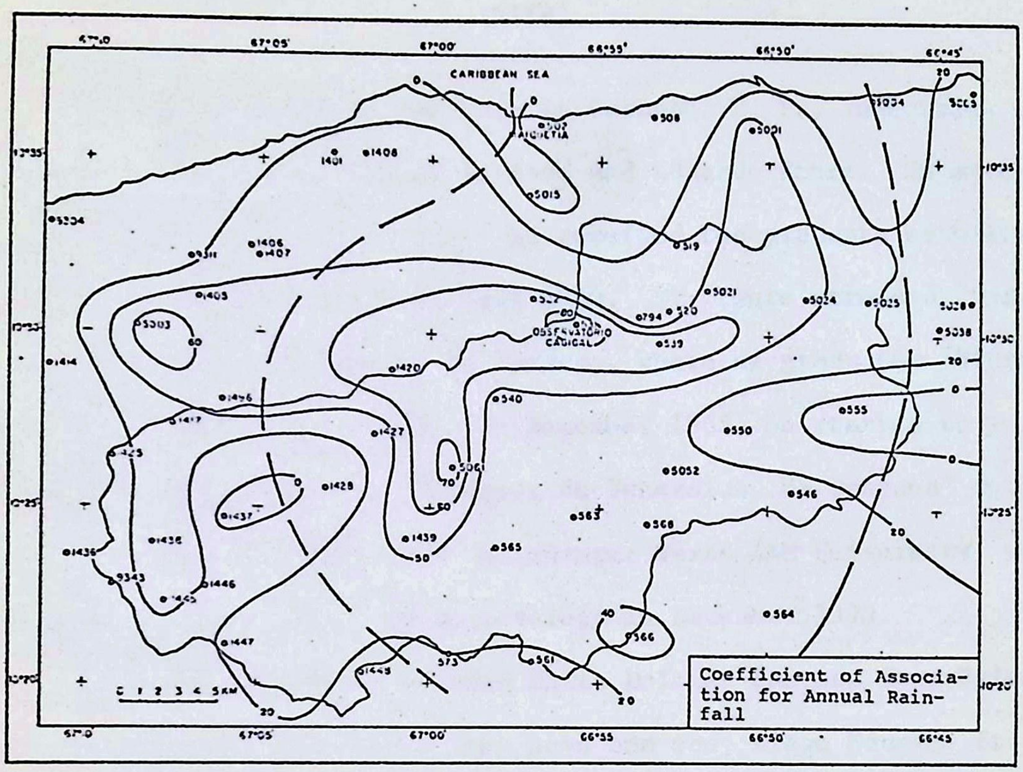
Coefficient of Association for Oct.



Coefficient of Association
for Nov.



Coefficient of Association
for Dec.



Coefficient of Association for Annual Rainfall

VITA

Ricardo R. Ponte R. was born in Caracas, D. F., Venezuela, on April 20, 1939, to Enriqueta Ramirez and Eduardo Ponte. He attended public school in Caracas, where he received the graduate bachelor from "Liceo Andres Bello" in July 1960. Mr. Ponte attended "Universidad Central de Venezuela" in Caracas, where he graduated "Hidrometeorologista" in April 1965. In December 1965, he started to work as hydrometeorologist at "Corporación Venezolana de Guayana" until December 1967. In July 1968, he entered Texas A&M University, where he earned a M.S. degree in Meteorology in December 1970.

Ricardo R. Ponte R. married Maria Dolores Sanchez from Palencia, Spain, on August 25, 1967. They have one son, Diego Eduardo from their marriage.

This thesis was typed by Mrs. Maria Dolores Ponte.