NASA CONTRACTOR REPORT

NASA CR-129030

(NASA-CR-129030) STUDIES IN THE USE OF CLOUD TYPE STATISTICS IN MISSION SIMULATION (Environmental Research and Technology, Inc.) 182 p HC $5.50 CSCL 04B G3/20

N74-30053

Unclas 54119

STUDIES IN THE USE OF CLOUD TYPE STATISTICS IN MISSION SIMULATION

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July 1974

Prepared for

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ACKNOWLEDGMENT

The authors wish to thank the staff of the Aerospace Environment Division, Marshall Space Flight Center, for their helpful suggestions. In particular, the support provided by Messrs. Clark Brown and Dale Johnson is gratefully acknowledged.

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1. INTRODUCTION

Clouds are a key factor to be considered in the planning of remote sensing missions of the earth's surface. Depending upon the extent and thickness of a cloud, and upon the wavelengths used by the spaceborne sensor, a cloud has effects on the measured radiation ranging from slight attenuation to total absorption. The complexity of modern remote sensing systems, with wavelengths in the visible, infrared, and microwave, necessitates detailed information on expected cloud cover, cloud type, and cloud levels (heights) to permit intelligent planning of earth sensing missions. In recognition of this fact, the Aerospace Environment Division at the Marshall Space Flight Center has sponsored the development of a global data bank of cloud statistics, and of computer techniques to utilize these statistics in mission simulations.

Concurrent with these studues, MSFC also sponsored the development of another data bank (Spiegler and Greaves, 1971; Spiegler and Fowler, 1972). This data bank, known as the 4-D Atmospheric Model, contains means and variances of atmospheric pressure, temperature, water vapor and density from the surface to twenty-five kilometers above the earth. Related computer programs were also written to permit the use of this data bank in specifying atmospheric profiles for any latitude, longitude and month of the year.

The current study covered several areas of research designed to refine, improve and extend these data banks. These topics included:

1) Investigation of regional homogeneity in regard to cloud type and cloud layer statistics for Regions 2, 11, 18, and 30

2) Investigation of the spatial and temporal conditionality of the cloud type and cloud layer statistics

3) Verification of the mathematical techniques used in mission simulation

4) Development of a mission simulation technique combining the cloud statistics and the 4-D atmospheric model

5) Development of cloud models corresponding to the cloud types used in the cloud type statistics

6) Recommendations for the extension and improvement of the 4-D atmospheric models.

For the reader unfamiliar with the previous reports, the history of this cloud study and the resulting computer models are summarized below. Section 2 presents the latest revisions to the data banks, Section 3 evaluates regional homogeneity in light of cloud types and number of cloud layers, and Section 4 investigates various forms of conditional probability. Section 5 presents a hypothetical mission simulation scheme designed to incorporate both the cloud statistics and the 4-D global atmospheric models and to evaluate a mission using amounts of integrated liquid water and water vapor as the criteria for success or failure. Section 6 proposes new models of cloud microstructure and the last section of the report recommends an approach to the extension of the 4-D atmospheric model to 50 km, and the incorporation of global wind statistics.

1.1 The Development of the Global Cloud Model

Three studies have preceded this current one. The first, by Sherr et al (1968) defined the basic guidelines for a global data bank of cloud statistics. The primary purpose for the development of this data bank was to provide information for the proper planning and analysis of earth-oriented space missions; hence, it was felt that climatological data of universal application was required, and that at least the following should be provided:

1) Global coverage
2) Cloud cover distributions in a readily usable, standard form.
3) Distributions by season, time of day, and some readily defined climatological region or grid.
4) Expression of the spatial and temporal coherence of cloud cover.
5) Expression of cloud cover distributions on a variety of scales of observation.

Based upon climatological considerations, 29 homogeneous cloud regions, with boundaries upon even latitudes and longitudes, were defined to represent the global cloud distribution. This facilitated the meeting of the above specifications without generating a data set too large or unwieldy to be of use. It would, of course, have been possible to define many more regions, indicating the great diversity of local climates, but the resulting increase in information would be negligible compared to the increase in difficulty in using the model. A representative station was selected for each region, and all data given for that station were assumed applicable to locations within that region.

To derive the actual cloud statistics, cloud cover summaries of 5 to 3 years of data were obtained from the Weather Bureau for each representative station. Cloud cover reports were grouped into five categories (Table 1-1) and frequencies for each of the five categories were derived for every region, for twelve months of the year, and for three-hour intervals throughout the 24-hour day beginning at 01 LST.

TABLE 1-1

CLOUD CATEGORY DESIGNATION

Category	Tenths	Eighths (Octas)
1	0	0
2	1,2,3	1,2
3	4,5	3,4
4	6,7,8,9	5,6,7
5	10	8

Spatial and temporal conditional statistics of cloud cover were also derived and were based primarily upon satellite photographs.

As a final task in the study, a Monte Carlo technique was developed whereby the unconditional and conditional statistics, in the form of cumulative probabilities, were used to simulate the cloud cover conditions for various orbital missions. With some modifications this simulation technique has remained the basic approach towards the application of the statistical data.

The second study, by Greaves et al (1971), continued the development of statistics and statistical procedures for cloud simulation in a number of areas. The most important of these was the development of a Markov scaling technique to scale the 24-hour and 200-mile conditional cloud cover statistics to any other time or distance scale. Also developed was a relationship between ground and satellite derived cloud frequency distributions. This relationship was used to introduce internal consistency between the ground-observed unconditional statistics and the conditional statistics derived from satellite observations.

Also in this study, a first attempt was made to establish some statistics for the occurrence of weather phenomena, other than clouds, such as tornadoes and severe thunderstorms, which are of significance to remote sensing of the earth's surface from most altitudes.

The cloud statistics were significantly altered and improved in the third study by Chang and Willand (1972). As stated above, the original data set had contained statistics only on cloud amount; this third study added information on cloud type and number of cloud layers. The same twenty-nine homogeneous regions were used, but to the original statistics were added frequencies of observed cloud types and observed cloud layers, stratified by total cloud amount. For clarity, the nine cloud type categories, and the cloud types they represent, are given in Table 1-2.

TABLE 1-2

CLOUD TYPE CATEGORIES

Cloud Type	Cloud Types Represented
Cu	Cumulus
Sc	Stratocumulus Cumulus Fractus/Fractocumulus
St	Stratus Stratus Fractus/Fractostratus
Cb	Cumulonimbus Cumulonimbus mamma
As	Altostratus
Ac	Altocumulus Altocumulus Castellanus
Ci	Cirrus
Cs	Cirrostratus
Ns	Nimbostratus

Many of the original stations selected for cloud cover statistics had also reported cloud type and number of cloud layers. When this was the case, the additional region statistics were derived for the representative stations used by Sherr et al. For other regions, new stations were selected, and several years of cloud type observations were processed from magnetic tape. Four regions had no data tapes available and it was necessary for these locations to use microfilm data. Because time and financial constraints limited the reduction of this data to a two-year period, the statistics for these regions are of poorer quality than those for other regions. One of the first objectives of the current study was to remedy this imbalance.

1.2 The Global Cloud Model Data Banks and Computer Programs

It is clear that a large amount of detailed, easily usable, data has resulted from these various studies. An example of the computer printout of the combined cloud type, cloud layer and cloud cover frequency is shown in Figure 1-1 and similar statistics for all regions are given by Chang and Willand in NASA CR-61389. This data, as well as data from the previous studies, have also been preserved on computer cards, and are referenced by specially designed software. Both the data and the programs are available from Mr. S. Clark Brown at the Aerospace Environment Division at Marshall Space Flight Center (MSFC). The following section will provide a brief summary of these models.

1.2.1 Existing Data Banks

At least three data banks relating to the global distribution of cloud cover have been derived and are reproduced as card decks. For convenience, arbitrary FORTRAN names have been assigned to each of these decks which are described below.

Local Standard Time

Frequencies of Observed Cloud Types

Frequencies of Observed Cloud Layers

Frequency Clear Sky

Cloud Cover Categories

MONTH 5 REGION 1

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST = 1													195
2	0	1	0	0	1	12	5	4	0	21	1	0	
3	0	0	0	0	0	5	3	2	0	8	1	0	
4	0	2	0	1	2	21	4	9	0	19	10	0	
5	0	0	0	1	1	12	2	7	0	8	6	1	
LST = 4													190
2	0	0	0	0	2	14	6	5	0	25	1	0	
3	0	0	0	0	1	9	3	2	0	11	2	0	
4	0	1	0	0	1	15	4	7	0	12	8	0	
5	0	0	0	1	2	12	0	5	0	6	7	0	
LST = 7													167
2	0	0	0	0	0	15	6	4	0	23	1	0	
3	0	0	0	0	0	3	8	1	0	12	0	0	
4	0	0	0	0	1	18	7	8	0	14	10	0	
5	0	1	1	0	4	13	0	11	0	6	12	0	
LST =10													154
2	1	0	0	0	0	13	13	8	0	25	5	0	
3	0	0	0	0	1	6	5	2	0	10	2	0	
4	1	0	0	0	1	11	7	8	0	11	7	1	
5	0	1	0	0	3	14	3	13	0	4	15	0	
LST =13													148
2	4	0	0	0	0	8	17	5	0	26	4	0	
3	0	0	0	0	0	4	7	2	0	5	4	0	
4	1	1	0	0	3	12	1	14	0	9	10	1	
5	0	0	0	0	2	13	2	15	0	6	13	0	
LST =16													160
2	2	0	0	0	0	12	7	3	0	20	2	0	
3	0	1	0	0	0	3	6	2	0	8	2	0	
4	1	1	0	0	2	14	11	18	0	13	17	0	
5	1	0	0	0	2	11	0	14	0	6	8	2	
LST =19													169
2	1	1	0	0	1	12	18	4	0	27	5	0	
3	0	0	0	0	0	2	0	3	0	5	0	0	
4	1	1	0	2	1	18	9	17	0	11	19	0	
5	0	2	0	2	2	13	2	7	0	5	10	1	
LST =22													202
2	0	0	0	0	0	12	7	6	0	23	1	0	
3	0	0	0	0	1	2	4	1	0	8	0	0	
4	0	0	0	0	1	9	4	13	0	11	8	0	
5	0	3	0	0	1	11	2	10	0	9	9	0	

Figure 1-1 Printout Format for Cloud Type and Cloud Layer Statistics

REGRID

This is a deck of 140 cards designed to locate any point on the earth, specified in longitude and latitude, in one of 29 cloud climatological regimes. These regimes were first defined by Sherr et al (1968), with each regime being assumed to be homogeneous in terms of the statistics of cloud cover and cloud type distributions.

CLOUDA

This deck of 1740 cards contains the cloud cover data for each of the 29 homogeneous cloud regimes first developed by Sherr et al and subsequently modified and expanded by Greaves et al (1971). Specifically, the data include probabilities of occurrence of percentage cloud cover at three hourly intervals for five categories of cloud cover, and for each month of the year. These unconditional probabilities were derived from surface observations. Also included in this data deck are spatial and temporal conditional probabilities, and unconditional probabilities, all derived for 1300 LST from analysis of satellite photographs. These cards then provide the basic data bank for cloud cover simulations.

CLOUDT

This deck of 5568 cards contains the cloud type and cloud layer probabilities recently developed by Chang and Willand (1972) for each of 29 cloud regimes. The probabilities are developed for nine main cloud types and for three cloud layer situations, all as functions of the four basic cloud cover categories (excluding the category describing clear skies). A separate set of these probabilities are available for each of the time intervals for which the unconditional cloud cover probabilities were previously developed.

CLOUDM

In addition to these data on cards, a set of representative values of in-cloud parameters for each of the nine basic cloud types has been developed based on a modification of the cloud models compiled by Gaut and Reifenstein. These parameters include cloud base altitude, cloud thickness, in-cloud distributions of liquid water content and drop size parameters.

1.2.2 Existing Simulation Software

A number of software packages were developed to apply the cloud statistics in computer simulations. These include the subroutines discussed below. Again, each subroutine is identified by a FORTRAN name for convenience.

REGION

This subroutine operates on the data from REGRID to transform an input specification of latitude and longitude (i.e., any point on the earth) into a specification of one of the 29 cloud climatological regimes.

SCALNG

This subroutine adjusts the conditional statistics to scales (of time and space) which are different from those at which the original conditional statistics were derived. In this particular subroutine the scaling is done by simply assuming that the conditionality decays linearly (with time and space).

JOINT

This subroutine is designed to be applied to the cloud statistics when the joint probability of occurrence of several events is required.

DICO

This subroutine computes a psuedo-conditional cloud cover probability to reflect diurnal variations in cloud cover.

MARKOV (formerly known as RASARA)

This is an improved scaling subroutine which does not assume a linear decay of conditionality. Instead, the decay of conditionality is based more on the properties of a Markov chain. This subroutine requires four additional routines listed below:

1. MARSCA
   This routine sets up parameters to be used in subroutine MATINV and MARKOV.

2. MATINV
   This routine does matrix inversion.

3. QARTIC

Performs calculations for the Markov scaling.

4. CORECT

This routine tests for convergence.

CTPROB

This subroutine calculates probabilities of cloud types, layers and amounts from the cloud type data bank (CLOUDT).

GETREG

This subroutine reads in REGRID cards and stores the data for processing in subroutine REGION.

1.3 The 4-D Atmospheric Model

Global data banks developed by Spiegler and Greaves (1971) and Spiegler and Fowler (1972), containing mean monthly profiles and daily variances of moisture, temperature, density and pressure from the surface to 25 km, are also available for computer mission simulations. These data banks contain grid point data at 3,490 locations on the globe, and regional data for 45 regions on the globe. Outlined below is a brief description of the existing data banks and software pertaining to the four-dimensional worldwide atmospheric models.

1.3.1 Existing Data Banks

Basically there exist four data banks relating to the four-dimensional worldwide atmospheric models. The names and descriptions of each of these data banks are as follows:

REGR4D

This is a deck of 156 cards designed to locate any point on earth, specified in longitude and latitude, in one of 45 homogeneous moisture regimes. These regimes were defined by Spiegler and Fowler (1972).

ACOEFF

This deck of 5400 cards contains the coefficients of the curve-fitted atmospheric profiles for each month for each of the 45 moisture regimes.

The curve-fitted profile for a single regime is the average of all profiles contained within that regime.

WWMDS

The worldwide meteorological data set (WWMDS) is stored on three 7-track, 800 bpi binary tapes labeled WW1A, WW2A and WW3A. In general, the tapes contain mean monthly profiles and daily variances of moisture, temperature, density, and pressure from the surface to 25 km for some 3490 points on the globe; these are actual data values computed for kilometer levels. There are 1513 of these points positioned at every 5° of latitude and longitude from the southpole to 15° north. The remaining 1977 points are contained within the National Meteorological Center (NMC) grid covering most of the northern hemisphere.

REGB

This data set was created by a special-purpose program, not described here, that reads in the data sets REGR4D and ACOEFF, reformats them and writes them on tape at 800 bpi, 7-track odd parity. This tape provides the input to program ANYRG described below.

1.3.2 Existing Software

Software packages have been developed to perform a variety of computations utilizing the four-dimensional worldwide atmospheric data bank. Names and descriptions of the software are listed below.

ANYRG

This program is designed to generate meteorological profiles at specific times and locations from the coefficients of the curve-fitted region data bank (REGB). The values it produces are not unique for each latitude and longitude for they are constant throughout a homogeneous moisture region. This design was introduced mainly to minimize data storage and processing time in future computerized simulations but it provides excellent reference profiles for locations across the globe.

ANYPT

This is a program designed to utilize the WWMDS data set in generating unique meteorological parameters for each latitude, longitude, month and level up to 25 km. Horizontal interpolation schemes written into the program allow one to take the existing data from the WWMDS data set and apply it to any location on the globe. Secondly, the data set (WWMDS) is available only at 1 km intervals from the surface to 25 km; this program, through the use of curve-fit routines (Spiegler and Greaves, 1971), can generate values at any level or series of levels within that range (i.e., 2.3 km, 7.6 km, 12.9 km). Thirdly, while tapes WW1A-WW3A contain a fixed set of data, this program can generate a new tape of profile coefficients for frequently used latitude - longitude points which might not occur in the original values. The resultant time-saving in tape reading and/or horizontal interpolation should be immediately apparent.

2. IMPROVEMENTS IN CLOUD TYPE STATISTICS

In the study by Chang and Willand (1972) the global cloud statistics data bank was significantly expanded. The original data bank consisted of cloud cover amounts for each of 29 homogeneous cloud regions; the 1972 study added statistics on cloud type and cloud layer. This permitted simulations to go far beyond expected coverage, and into expected cloud conditions at various levels of the atmosphere. Much of the cloud data used in this expansion corresponded to the original data which generated cloud cover statistics (Sherr et al, 1968); however, certain regions had no cloud-type information in the original data tapes. For these regions (6, 10, 15, 17) several years of microfilm data were obtained; unfortunately, time limitations prevented the reduction of more than two years of data. Since at least five years of observations are desirable to obtain a valid statistical sample, one of the first objectives of this study was to replace these microfilm statistics with longer periods of record wherever possible.

Although no further cloud data was available for Regions 6 and 17, 10 years of data on magnetic tapes were obtained for Kunsan, Korea in Region 10 and Thule, Greenland in Region 15 (see Table 2-1). These observations were processed using software developed under the previous contract, and printed out at three-hour intervals for each month of the year and for each of the four non-clear sky cloud cover categories. The resulting cloud statistics, with those for the Antarctic Region 24 (the seasonal reversal of Region 15) are printed in Appendix A. They also have been incorporated in card deck CLOUDT (see Section 1.1) and have thus replaced the statistics previously obtained for Regions 10, 15, and 24.

The new cloud statistics are superior to the old in more than just length of record and data sample size. They are also stratified by cloud cover amount; the microfilm data was processed only by cloud type. In the original data set the two-year frequency given for each cloud was assigned to all four cloud amount categories; this not only gave the same cloud probabilities to all sky cover amounts (except clear), it falsely raised the sample size to that representative of 8 years. The ten years of record used here provided accurate frequencies of both cloud amount and cloud type. No clear-day data was given in the initial sets; it was assumed that such data would be obtained from the original cloud amount data bank. The revised statistics for these three regions include clear-sky frequency values.

For Region 10, another problem was the lack of time dependence in the original data set. The Pelly Bay observations were available only at six-hour intervals; Kunsan's observations permit statistical sets for each of the standard three-hour periods. The amount of difference in the cloud type statistics for January caused by these various differences in the data set is seen in Figure 2-1. The original statistics are the same for LST=01 and 07, and report only stratocumulus and stratus. The revised statistics differ for these observation times, and also show significant occurrences of other cloud types. Whether stratus or stratocumulus has the maximum probability of occurrence is unknown; the striking difference between the two stations may reflect unlike meteorological conditions or, more likely, observer bias. The daytime statistics (13 and 19 LST) are even more dissimilar; in fact there is little resemblance between the two stations.

When the cloud type statistics are averaged across the eight time periods, many of these differences become less pronounced. The stratocumulus and stratus still show the highest frequency in January (Figure 2-2), and there still seems to be much more cirrostratus at Kunsan; however, most other probabilities agree within 0.05 during both January and July. This is mainly due to the increased sample size in Pelly Bay; summed across all time periods, the data set may be approaching a statistically valid sample and thus should be in agreement with the data set for Kunsan.

The probability of a given number of cloud layers shows a totally different pattern. In January, the two sets of data are very similar; in July they are totally unlike. The reason for this discrepancy is not readily apparent; perhaps Pelly Bay simply prefers to report one cloud layer. Since no statistics on cloud cover (or lack thereof) were included in the original data, the lack of agreement in cloud cover amounts is not only expected, it is desired.

Greater changes in the cloud type statistics are seen in Region 15 (Figure 2-3); in fact the January values do not agree. As Resolute, Canada, and Thule, Greenland, do tend to be quite similar climatologically, these differences are probably due to sample size only. On the other hand, the number of layers expected for the two stations are almost indistinguishable. July shows a greater similarity in cloud types, indicating (with the results of Region 10) less variability during this season and thus a smaller sample size needed for statistical stability. However, it is clear that the statistics for Region 15 are not yet in total agreement. The same curious pattern seen in Region 10 occurs for the number of cloud layers; evidently short time periods lend undue emphasis to the frequency of one cloud layer.

TABLE 2-1

CLOUD TYPE DATA FOR REGIONS 10 AND 15

Region	Original Cloud Type Statistics			Revised Cloud Type Statistics		
	Station	Period of Record	Time of Observation	Station	Period of Record	Time of Observation
10	Pelly Bay (Canada)	1 Jan 66 - 31 Dec 67	6-Hour intervals at 05, 11, 17, 23 LST	Kunsan (Korea)	1 Apr 51 - 31 Dec 60	3-Hour intervals starting at 01 LST
15	Resolute (Canada)	1 Jan 64 - 31 Dec 65	1-Hour intervals on the hour starting at 01 LST	Thule (Greenland)	1 Sept 51 - 31 Dec 61	3-Hour intervals starting at 01 LST

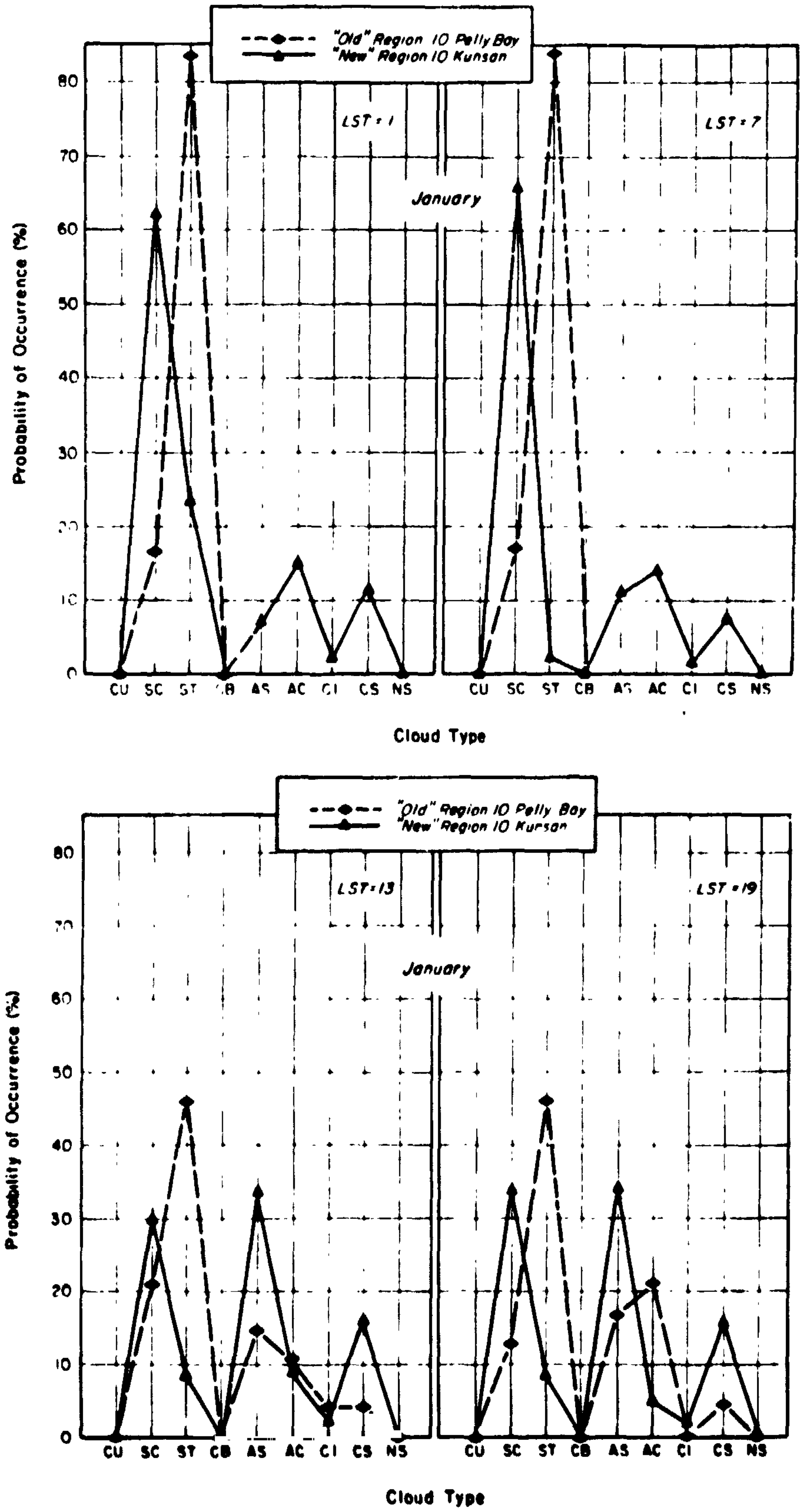
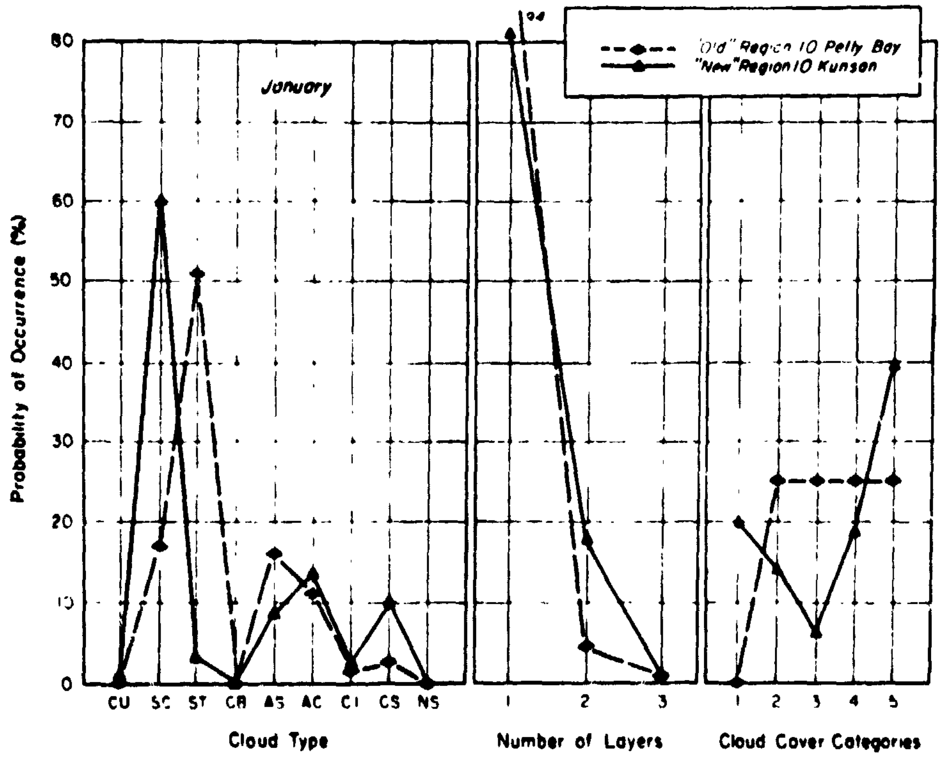


Figure 2-1 Hourly Cloud Type Statistics for Region 10



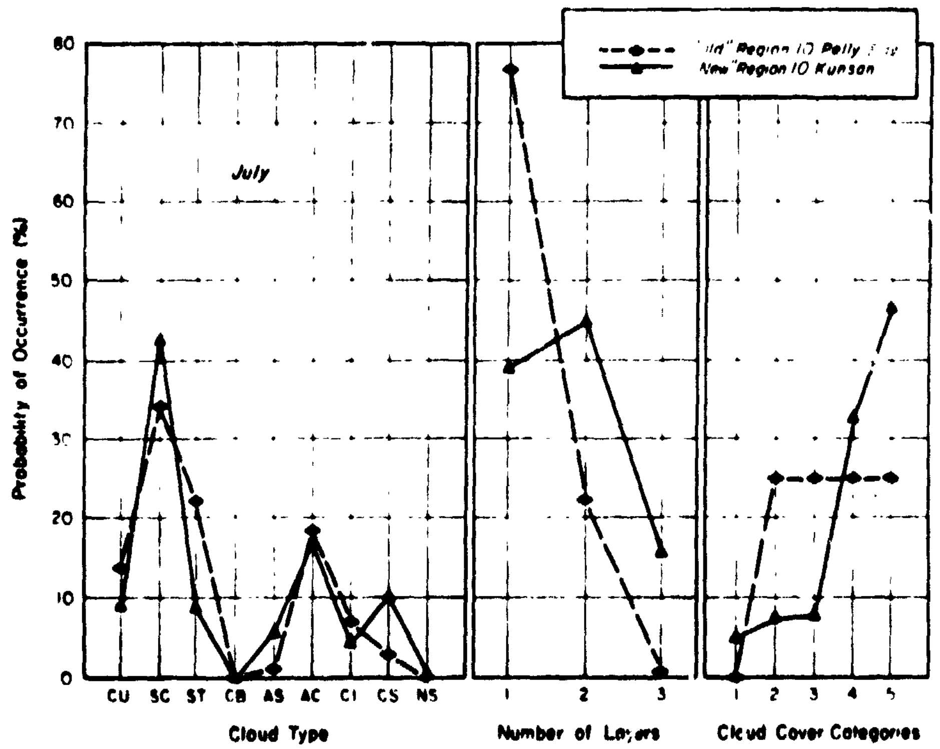


Figure 2-2 Cloud Statistics for region 10

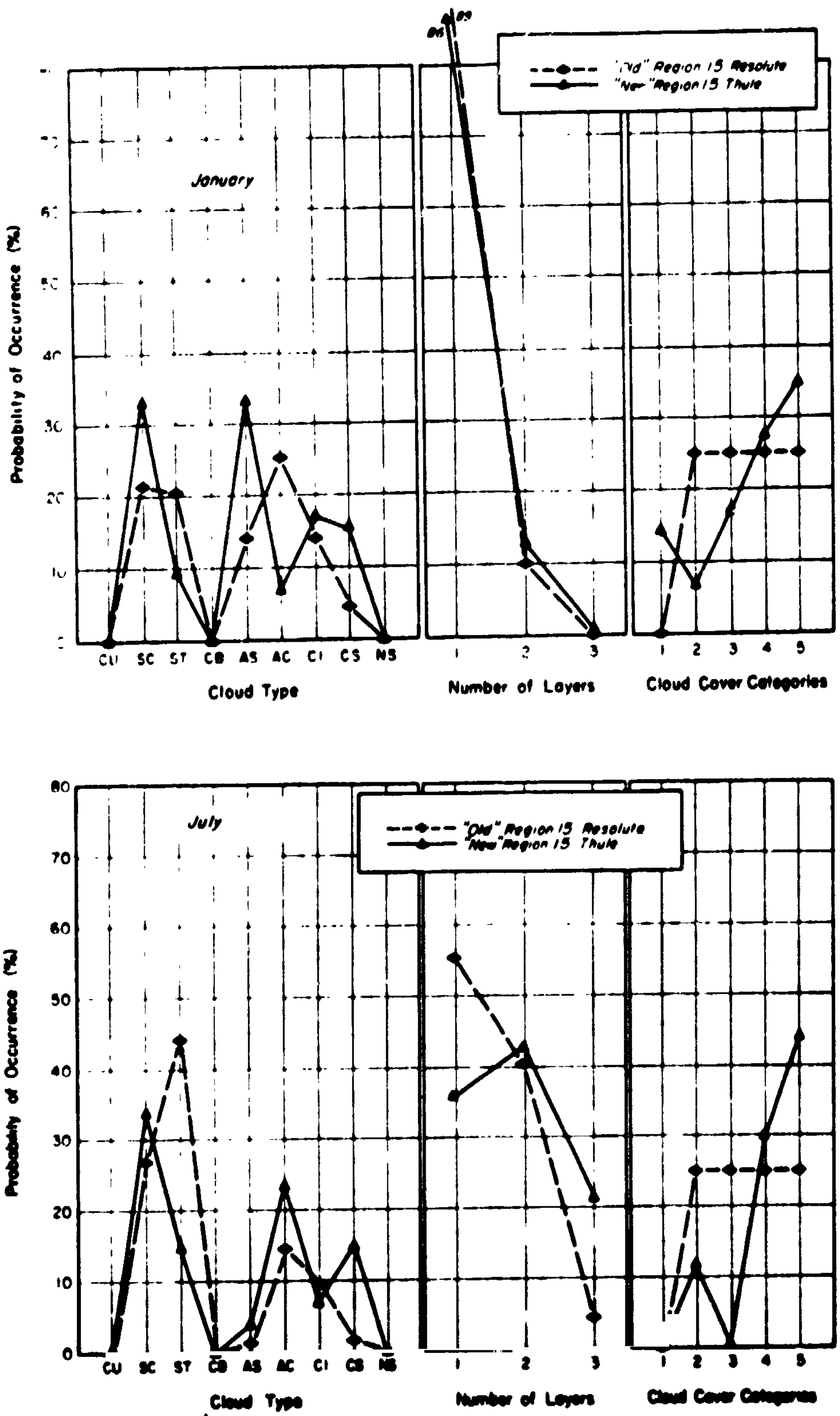


Figure 2-3 Cloud Statistics for Region 15

3. EXAMINATION OF REGIONAL HOMOGENEITY

3.1 Regional Similarities

The basic concept of the global cloud statistics model is that of homogeneity; that is, the assumption that a limited number of cloud climatological regions can adequately describe the global cloud distribution. Climatological analysis led Sherr et al to define 29 such homogeneous cloud regions and to select a representative station for each region. The statistics of cloud cover derived for each station were assumed applicable to all points within that region; subsequent comparison of cloud cover statistics for a number of locations within a cloud regime has supported this assumption (Sherr et al,1968; Chang and Willand, 1972).

The expansion of the cloud statistics to include cloud type and cloud layer statistics retained the regional boundaries defined by cloud cover amount. At the time, no investigation of regional homogeneity of cloud layer and cloud type was made; the following analysis was designed to look into this problem.

Three regions were selected for study: Region 2, noted for its small amount of cloudiness; Region 18, characterized by extreme seasonal changes; and Region 11, the midlatitude land region. Table 3-1 provides a general description. (Also included in Table 3-1 is a description of Region 19. The statistics from this region are used in a subsequent discussion of difference in statistics between adjacent regions.) Clearly, these regions are representative of most possible cloud cover situations. To perform the analysis, a number of stations were chosen within these regions; Table 3-2 presents these stations and the years for which the WBAN cloud data was obtained.

Figure 3-1 allows the advantages of this selection to be readily seen. First, the stations provide a comparison between locations on the boundary of a region (e.g., Belleville, Illinois) with locations well within a region (e.g., Chicago, Illinois). Secondly, many of the stations are oriented along an east-west or a north-south axis (that is, parallel or perpendicular to the movement of most storm systems). This facilitates an analysis of spatial conditionality both within a region (Region 11) or

TABLE 3-1

GENERAL DESCRIPTION OF CLIMATOLOGICAL REGIONS

1	2	3	4	5	6	7	8	9
Region Number	General Description	Location	Seasonal Change in Cloud Amount	Mean Monthly Cloud Amount Jun-Aug (in %)	Mean Monthly Cloud Amount Dec-Mar (in %)	Predominant Cloud Type	Diurnal Variation in Cloud Amount	Hour of Maximum Cloud Amount (Local Time)
02	Little Cloudiness	Sub-Desert Areas	Small	<40	<40	--	Small	--
11	Midlatitude - land	Northern Hemisphere	Moderate	~50	~70	Synoptic Scale	Small	--
18	Mediter-ranean	Northern Hemisphere	Extreme	~30	--	Convective	Small	--
		Europe, Western North America		--	~60	Synoptic Scale	Small	--
19	Subtropical	Northern Hemisphere 30N	Moderate	50 --	-- 60	Convective Synoptic Scale	Large Small	1600 --

TABLE 3-2

CLOUD DATA AVAILABLE FOR DETAILED ANALYSIS

Region	Station Number	Station Name	Period of Record (Year and Month)
2	23169	Las Vegas, Nevada	5801 - 6712
2	33123*	Tripoli, Libya	5801 - 6712
11	13802*	Belleville, Illinois	5801 - 6712
11	94846	Chicago (O'Hare), Illinois	5801 - 6712
11	14842	Peoria, Illinois	5901 - 6712
11	13983	Columbia, Missouri	5801 - 6712
11	13988	Kansas City, Missouri	5801 - 6712
18	93104	China Lake, California	5801 - 6712
18	23234*	San Francisco, California	5801 - 6712

*Representative station for that region; cloud data available from previous studies.

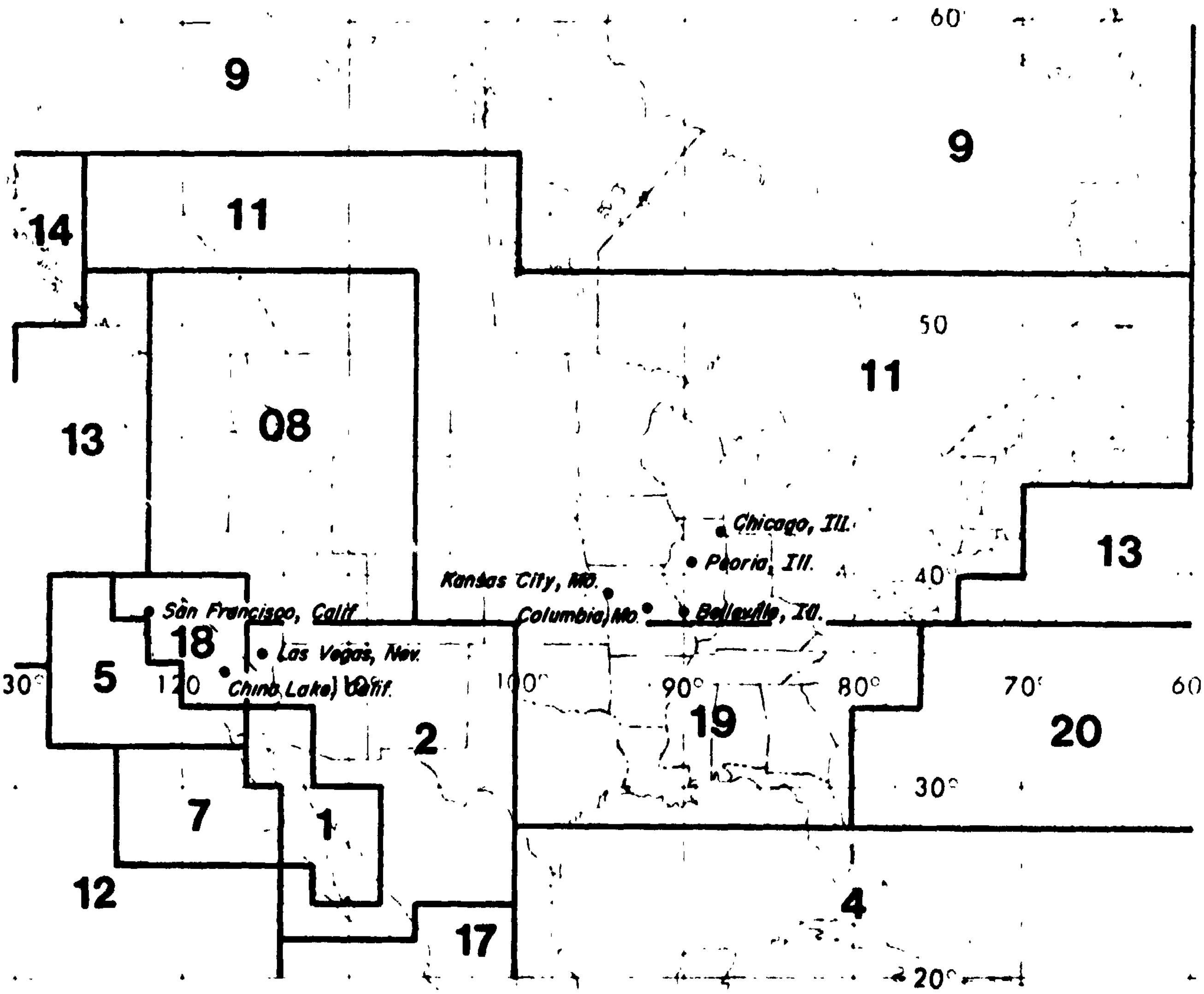


Figure 3-1 Location of Selected Stations

across regional boundaries (Regions 18 and 2). Thirdly, the climatological and topographical differences between the Midwestern States, and the Pacific States provide an interesting contrast not only in the overall cloud statistics, but also in their spatial and temporal decay.

To simplify the analysis the monthly frequencies given for the eight time periods were combined into one set of observations for an entire season. This not only made the samples time-independent, eliminating the need for nighttime-daytime comparison, it also provided data samples large enough to be statistically stable. Possible anomalies caused by missing or erroneous data should thus be minimized, and remaining differences should reflect lack of climatological homogeneity rather than numerical inconsistencies. Two seasons were compared - winter (December, January, and February) and summer; these are the seasons given in the initial region specifications, and should certainly show the most contrast.

3.1.1 Region 11

Region 11 is defined as the midlatitude land region with a predominance of synoptic scale cloud situations and a mean cloud cover ranging from 50% in the summer to 70% in the winter. Significant differences would be expected across the five stations selected since Belleville and Columbia are often under the influence of the northern edge of the intrusion of warm air from the Gulf of Mexico, and the weather at Chicago is generally dominated by air off Lake Michigan. Therefore, the pronounced similarity in the cloud statistics seen in Figure 3-2 indicates a rather remarkable amount of homogeneity. For most of the cloud types, differences in probabilities are less than 0.05; in fact, the greatest divergence from the modal value computed from all the stations analyzed for this region is found in the statistics for Belleville, Illinois - the representative station. In the cloud types this would seem to reflect a bias in reporting as the cirrus probability is much lower, and the cirrostratus much higher, than it is for the other stations in Region 11. Since it is not difficult to confuse cirrus and cirrostratus, the divergence of these statistics probably has little meteorological significance.

The other cloud type which shows a probability difference of greater than 0.05 is stratocumulus which in the winter ranges from a 21% likelihood

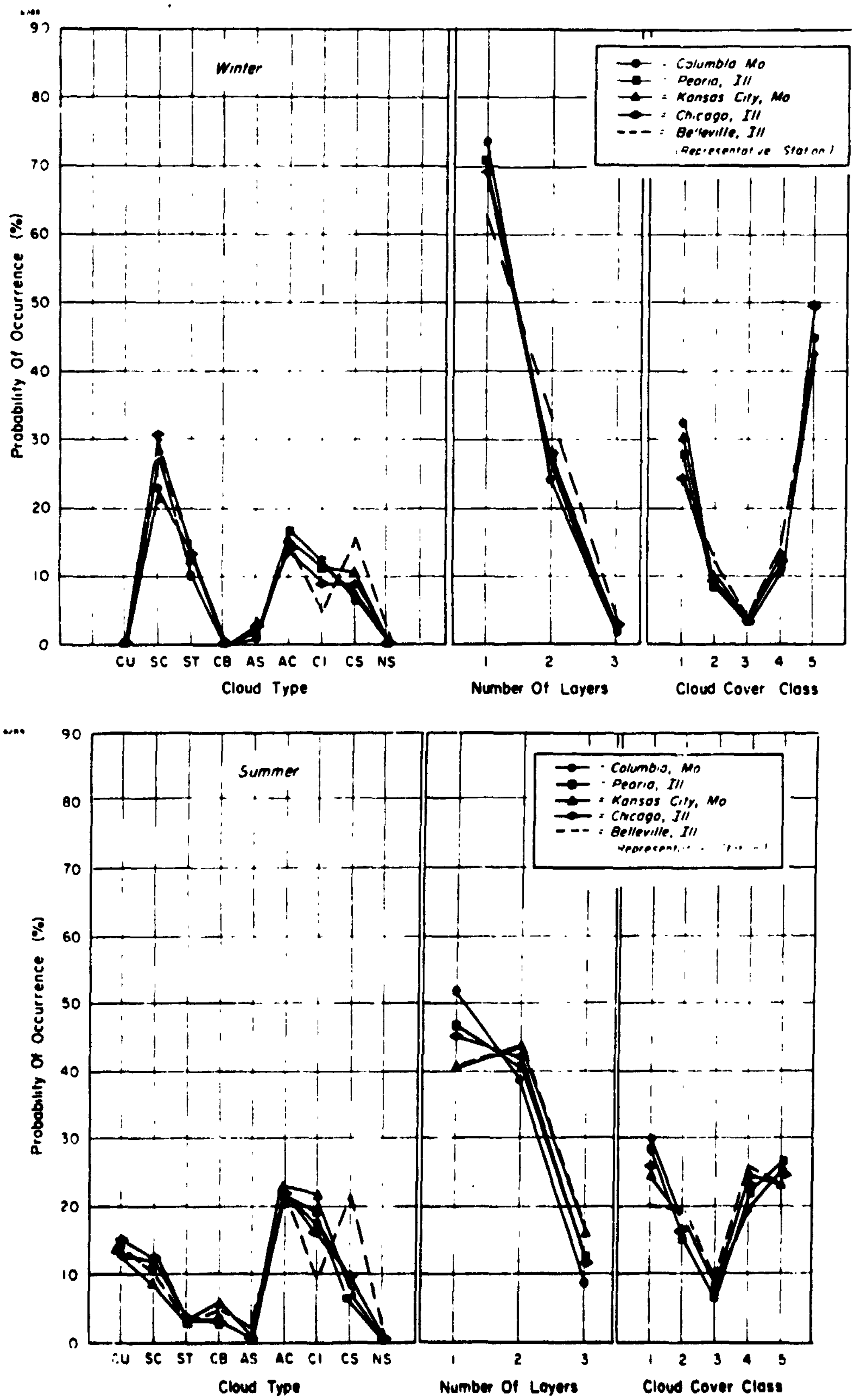


Figure 3-2 Cloud Statistics for Region 11

in Columbia to a 31% likelihood in Chicago. This increase in probability generally corresponds to a move northward in location and probably reflects actual meteorological differences across this area. An examination of the cloud cover statistics supports this theory; Columbia has the highest probability of clear skies and Chicago the highest probability of overcast. Thus, while the homogeneity of cloud type in this region is clearly evident, and sufficient to justify the use of a representative station, the actual differences in climate and predominant air masses can be detected in a station analysis.

3.1.2 Region 2

Since its first publication by Chang and Willand (1972), the cloud-type statistics for Region 2 have drawn considerable comment as being unrepresentative of stations in the desert areas of southwestern United States. The results of this particular analysis - comparison between Las Vegas and Tripoli - are particularly important.

In contrast to the homogeneity seen in Region 11, the differences between Las Vegas and Tripoli in Region 2 seem quite large (Figure 3-3); in fact, it would appear that Region 2 shows "regional homogeneity" to a lesser degree than Region 11. The contrast between the two stations may be somewhat deceptive; if statistics from other stations within the region were available, one of these stations might be proved anomalous or they both might be shown to represent extremes. At any rate most of the cloud types agree within 10%, many within 5%, especially in the winter. The expected cloud types in the summer differ markedly with Las Vegas experiencing much high-level cloudiness, cumulus, and thunderstorms while Tripoli shows no cumulonimbus, little cumulus, and a significant probability of stratocumulus or stratus. The presence of summer thunderstorm clouds in Region 2 statistics was also noted by Des Jardine (1958) in his analysis of cloud statistics for Tucson, Arizona. The frequency of clear skies differs for both seasons; in the winter clear skies are 20% more likely in Las Vegas than in Tripoli, in the summer, 10% less likely. Although the probabilities of cloud cover categories 2, 3 and 5 agree well, a difference appears for category 4 which is 10% more likely for Tripoli in the winter and for Las Vegas in the summer. Likewise, there are large differences in the

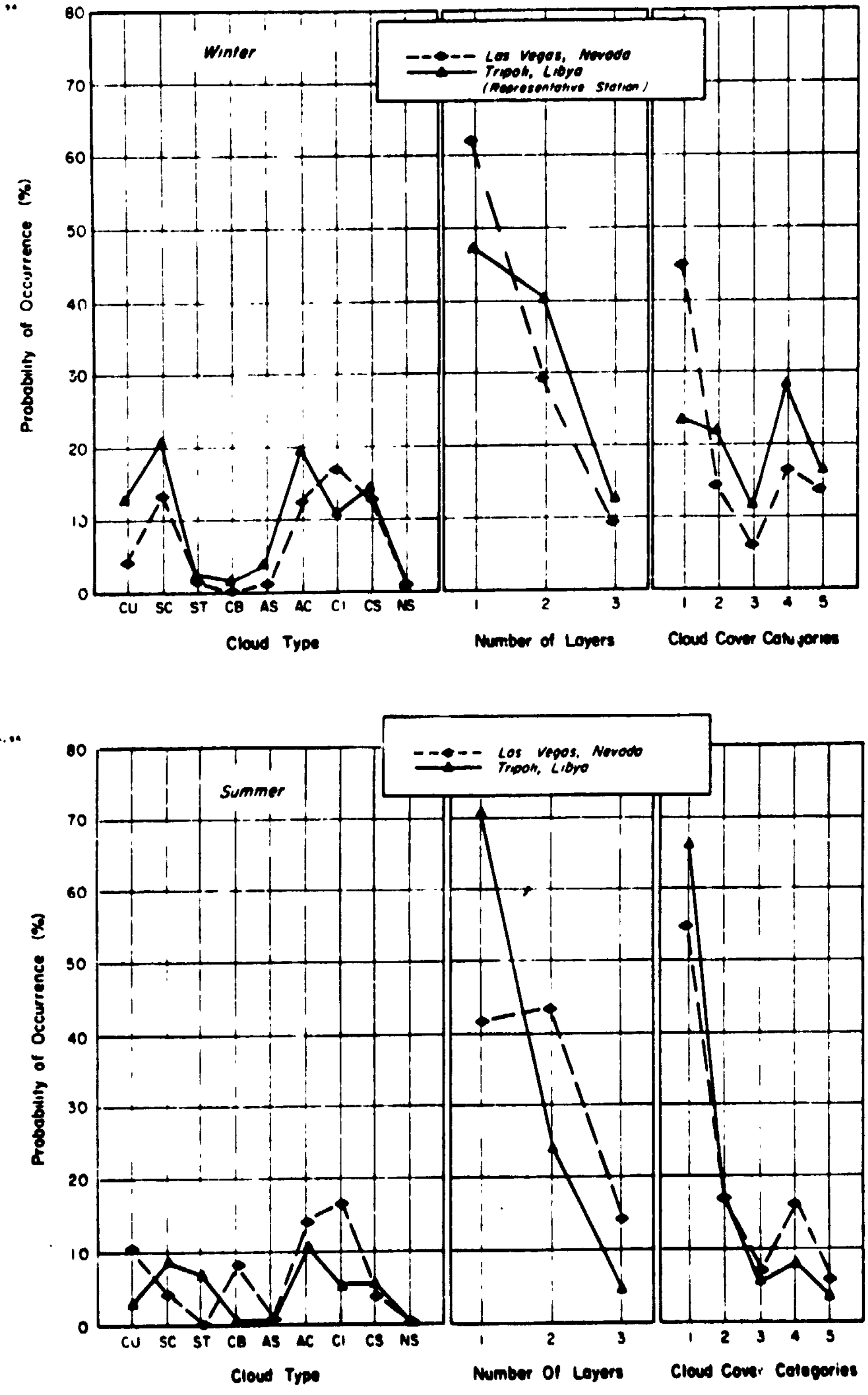


Figure 3-3 Cloud Statistics for Region 2

expected number of cloud layers. This region, as far as cloud type statistics are concerned, appears not to be as homogeneous as the cloud cover statistics would indicate. The similarity between the Las Vegas statistics and those obtained by Des Jardine for Tucson further suggests that the Tripoli statistics are not representative of Region 2 statistics for the United States. It should be noted, however, that Las Vegas better fits the characteristics of small seasonal change and less than 40% cloudiness ascribed to this region (see Table 3-2). In view of these differences, a new region was defined, Region 30, to better describe the cloud type statistics for the southwestern deserts of the United States.

3.1.3 Region 18

The two stations from Region 18 shown in Figure 3-4 correspond much better than those shown in Figure 3-3. However, the fact that the representative station for this region, San Francisco, is highly influenced by the Pacific Ocean, and China Lake is in a much drier area inland separated from the coastal air masses by a mountain range, does result in significant differences. In fact, the inclusion of China Lake as part of Region 18 is the result of the original requirement (Sherr et al, 1968) that boundaries of regions should fall on even values of longitudes. The largest differences occur in the probabilities of stratus and stratocumulus clouds; San Francisco shows a 31% likelihood of stratus in the summer, while China Lake reports none at all. These clouds correspond, of course, to San Francisco's coastal stratus, and to the high frequency of stratiform clouds rolling into the Bay area off the ocean. Related large differences are seen in the probabilities of overcast and clear skies with San Francisco favoring the former and China Lake favoring the latter.

In light of these localized differences, the general agreement seen in the expected cloud types and their probabilities seems quite good. China Lake's summer does indicate convective clouds; these are not paralleled in San Francisco. The winter data also indicates a 12% greater likelihood of one cloud layer for China Lake; other than these indicated discrepancies, the statistics match rather well. It would seem, however, that China Lake might be more representative of inland stations similar to Las Vegas in Region 2.

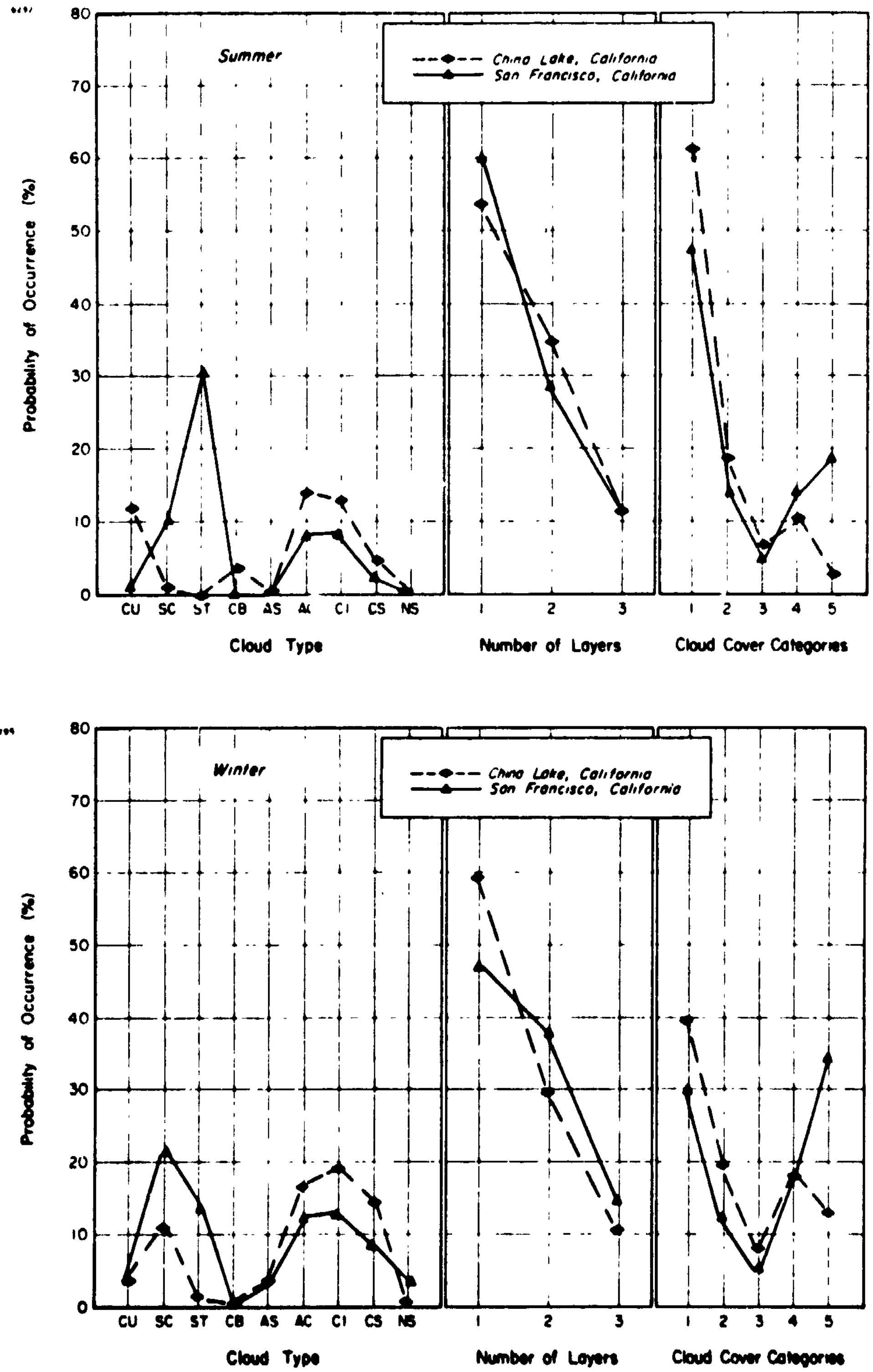


Figure 3-4 Cloud Statistics for Region 18

3.2 Examination of Regional Differences

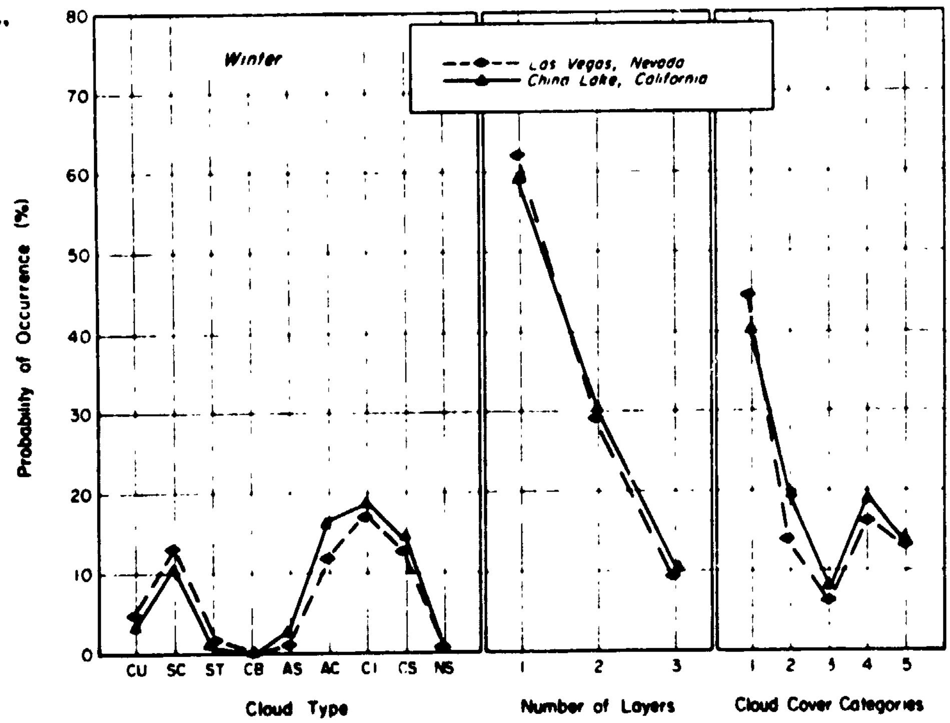
The previous section investigated the differences in cloud types and number of layers within "homogeneous" regions; this section will investigate differences across these regions to see how they compare with differences within regions. Sudden, sharp changes in cloudiness are not expected when a region boundary is crossed; on the other hand, it would be hoped that a greater similarity in cloud patterns is found within a cloud region than across two cloud regions.

3.2.1 Region 18 versus Region 30 (Old Region 2)

Although significant differences were found between the two stations originally located in old Region 2 and between the two stations in Region 18, no such differences are found between Las Vegas in Region 30 and China Lake in Region 18. Statistics on cloud type, number of cloud layers, and cloud cover categories all agree; only the summer probabilities for the one layer and two layers of cloud differ by more than 0.05. Figure 3-5 shows a homogeneity which far exceeds that in either of the regions examined and creates some doubt as to the validity of the region boundary between the two stations. Of course, these stations lie only 120 n.mi. apart (as close together as Kansas City and Columbia, Missouri) and much closer than San Francisco and China Lake, to say nothing of Las Vegas and Tripoli. Yet the concept of cloud homogeneous regions was based on climatological similarity, rather than geographical proximity. The results shown in Figures 3-4 and 3-5, further suggest that the area of Region 18 east of the Sierra Nevada, as represented by China Lake, should in fact be included in Region 30 and that the eastern boundary of Region 18 should follow the ridge line of the Sierra Nevada mountains.

3.2.2 Region 11 versus Region 19

A different approach was taken in the comparison of these two regions, primarily because of the greater number of stations available. Cloud type probabilities were averaged for the five stations in Region 11 (Chicago, Peoria, Belleville, Columbia, and Kansas City) and the resulting statistics for 00 and 12 LST were compared with those for Belleville, the representative station for Region 11, and with those for Shreveport, Louisiana, the representative station for Region 19. Figure 3-6 shows these probabilities for overcast conditions in



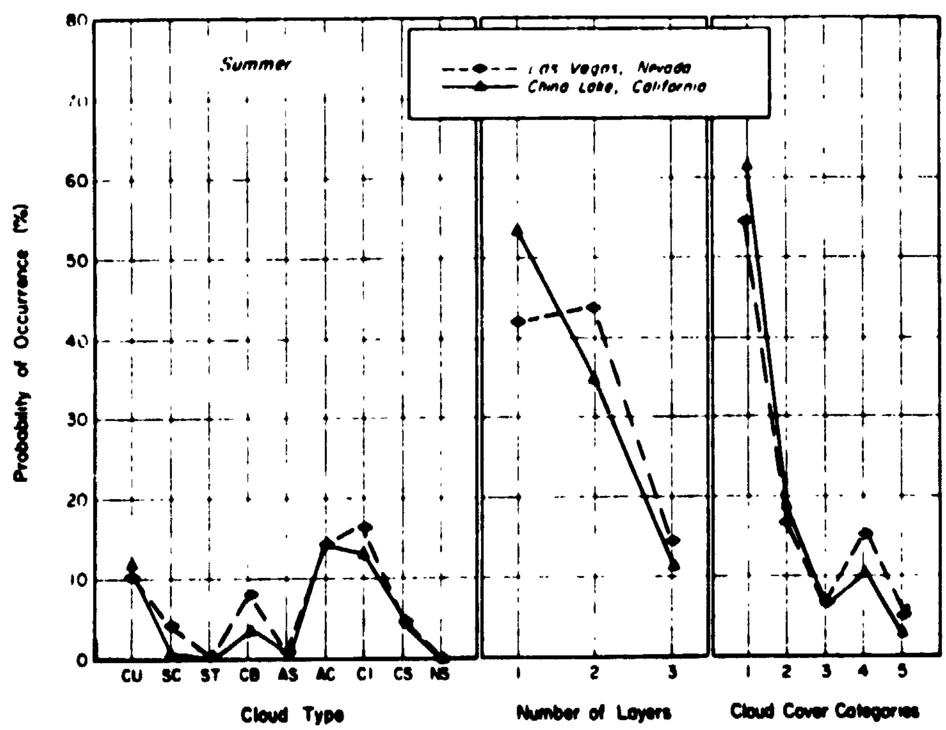


Figure 3-5 Cloud Statistics for China Lake, California and Las Vegas, Nevada

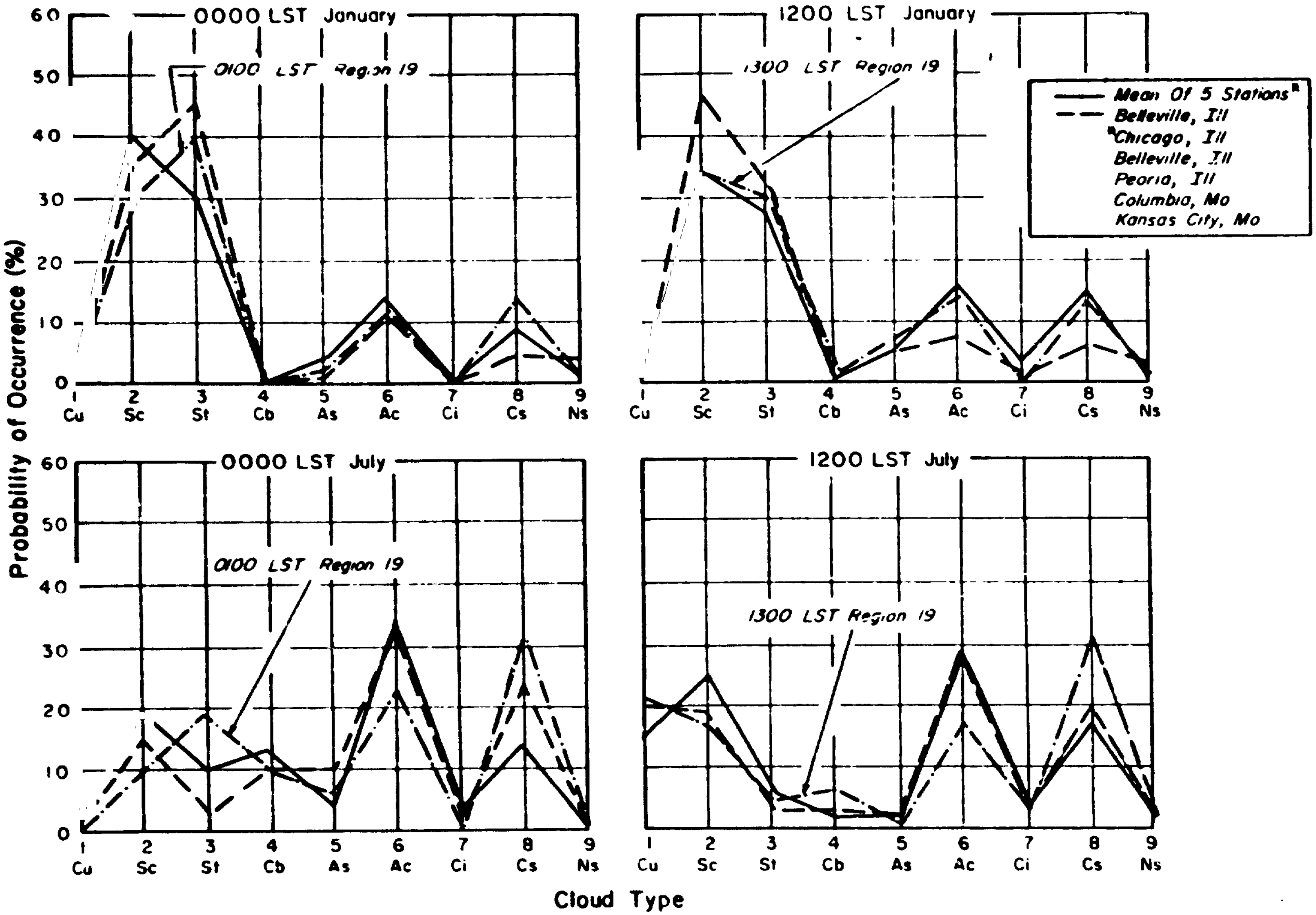


Figure 3-6 Selected Cloud Statistics for Regions 11 and 19

January and July; both regions show this cloud condition 50% of the time in January and 20% in July.

The homogeneity of Region 11 was examined in Section 3.1.1; there it was seen that the five stations showed remarkably similar cloud conditions, with Belleville's cloud statistics being the least typical in the region. Region 19, defined as the subtropical region, lies just to the south of Region 11; three of Region 11's stations (Kansas City, Columbia, and Belleville) fall quite close to this region boundary. As these stations often seem more subtropical than midlatitude in character, especially in the summer, it seemed of interest to investigate the homogeneity of the entire midwestern area.

The statistics for January are very similar for both 00 LST and 12 LST; in fact, Shreveport would appear to represent Region 11 better than Belleville does. This is especially true during the day when Belleville reports significantly more stratiform clouds, and significantly less cirriform clouds, that do the other stations. Since the analysis on regional homogeneity showed Belleville to be anomalous, a comparison of Belleville and Shreveport is obviously invalid, and shows the danger of comparing cloud type at just two stations to determine regional similarities.

Significant regional differences do appear in the July data; despite its apparent uniqueness (see Section 3.1.1), Belleville bears a much stronger resemblance to the mean of Region 11 than does Shreveport. The graph of cloud-type probabilities for Shreveport shows a very different character from the graphic plots for Region 11, with the most pronounced differences seen at both times for altocumulus and cirrostratus. During the night, the probabilities also differ by more than 0.05 for stratocumulus and stratus; in fact, the 00 LST data show little similarity between the two areas.

This limited set of cloud-type data reflects the climatological differences between the midlatitude and the subtropical cloud regimes and justifies the regional definition for these important regimes. The first is dominated by synoptic scale systems year round; the second is influenced by synoptic scale systems in the winter but dominated by convective activity in the summer. Thus the good fit on the January overcast conditions corresponds to the southerly location of the jet stream at that time and to the related dominance of cyclones and anticyclones over the entire Midwest. The July differences, however, indicate that Shreveport is dominated by hot, humid air off the Gulf of Mexico, and is south of the storm systems which still cross Region 11. The more southerly stations in Region 11 are also affected by the Gulf air but it would seen that their overcast conditions, at least, are more frequently associated with fronts.

3.3 Summary

The revision of the cloud data sets, and the analysis of regional homogeneity, indicate that much work remains before a definitive statement can be made on the correlation of the global distribution of cloud cover amount to that of cloud type probability. The major problem in determining this relationship does not seem to lie in the lack of regional differences, rather the representativeness of the stations given for each region, or possible initial errors in the region boundaries, seems to be more important.

Representative stations were chosen for each region according to the cloud data available at the station, with stations lying well within the region given priority over stations near the boundaries. In general, this led to very reliable results, but observer bias, or local orographic effects, caused occasional anomalies which were impossible to predict. The restriction of region boundaries to even degrees of longitude also created some difficulty since geological and meteorological changes are not constrained by geographical limits and thus a few stations appeared in regions geographically where they did not belong climatologically. In mission simulation and general climatology these anomalies cause little difficulty and normally can be ignored. In an analysis of regional homogeneity, or a study of differences between regions, these problems can have a much greater impact and require careful assessment. However, if these problems are taken into account, the following points can be ascertained:

- There is great danger in comparing "representative" stations to determine regional differences, if the representativeness of the stations has not been adequately established.
- Five stations from Region 11, representative of stations dominated by synoptic scale weather patterns, show an excellent amount of agreement and indicate that cloud cover homogeneity may also be reflected in cloud type and layer homogeneity.

- China Lake and Las Vegas have almost identical cloud conditions, indicating that the original region boundary between them was misplaced, not that Regions 18 and 2 are alike. This region boundary has been shifted to correspond more precisely with the mountain range (Figure 3-7).

- Initial comparison of Regions 11 and 19 shows significant differences between the two regions providing initial justification of the regional boundaries in these important midlatitude climatic regimes.

- The cloud type data for Tripoli, Libya (Region 2) does not represent the southwestern United States. A new region, Region 30, has been defined for this area and uses Las Vegas as a representative station (Figure 3-7) for cloud type probabilities. New cloud type and cloud cover statistics for this region are included in Appendix A.

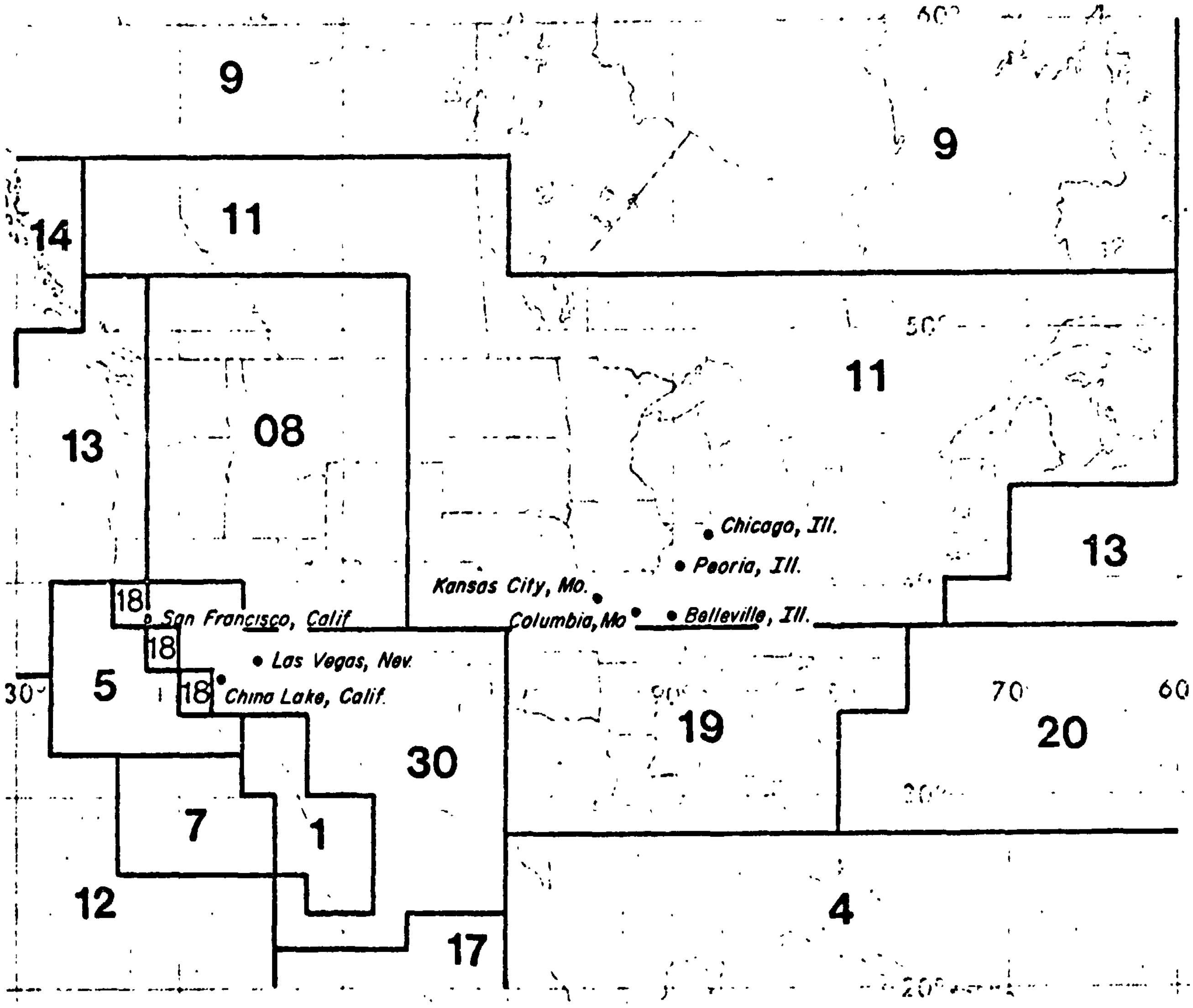


Figure 3-7 Map of Revised Regions

4. INVESTIGATION OF CONDITIONAL PROBABILITY

The cloud type and layer statistics analyzed in the previous section were basically unconditional statistics, stratified only by season. However, even the most elementary knowledge of clouds makes it clear that there are many types of cloud conditional statistics which need to be considered in any simulation scheme. The most obvious of these are the spatial and temporal conditional statistics. From a purely synoptic and climatological point of view, one can expect that certain types of clouds would have a greater degree of conditionality, in both the spatial and temporal senses, than other types. Convective clouds of the cumulus and cumulonimbus type, for example, occur at time and space scales greatly different from those of the stratiform type. Whether these differences in scale are manifested as significant differences in conditional statistics remains to be demonstrated.

A second class of conditionality is based on the fact that certain types of clouds are found associated with one another more often than with other cloud types. As an extreme example, one may consider the case of cumulonimbus clouds as the primary cloud layer. If a second layer is present, it is highly unlikely that this layer be low stratus simply from a priori knowledge of the different physical processes which form stratus and cumulonimbus. On the other hand, the same physical processes which gave rise to cumulonimbus are most likely to result in the formation of cirrus or cirrostratus as a second layer. Since the cloud layer statistics were derived independent of the cloud type statistics, it is possible with the present statistics that cumulonimbus and stratus be selected as the primary and secondary cloud layers, respectively.

This section will investigate these various types of conditionality to determine their magnitude and to ascertain their importance in cloud simulations. It will also examine a different type of temporal conditional, the diurnal cycle in the number of cloud layers.

4.1 Temporal Conditional Probability

Many users of the cloud statistics need information on the likelihood of a cloud situation persisting over a significant period of time. This persistence is very highly dependent on cloud type and on the meteorological conditions related to that cloud type; less of a dependence would be expected on the number of cloud layers, or on the total cloud amount. Hence, the temporal conditional statistics examined here are stratified only by cloud types.

To compute temporal conditionals, a computer program was written that, given a predominant cloud type C_i at time k, computes the probability of finding a predominant cloud type C_j at a fixed time increment, Δt, later. To make the analysis time independent, summations were performed with k = 0 LST, 3 LST ... 21 LST for each month in the 10-year sample. Defining S_{ij} as the sum of all occurrences of C_j given C_i across all times k, the temporal probabilities were computed as

$$P_{(j|i)} = \frac{S_{ij}}{\sum_{j=0}^{9} S_{ij}} \quad \text{for } \Delta t = 3 \text{ hr, } 6 \text{ hr, } 12 \text{ hr.} \qquad (4\text{-}1)$$

The resulting temporal probabilities were plotted for January and July for four stations: Kansas City, Missouri; Columbia, Missouri; China Lake, California; and Las Vegas, Nevada. Along the side of these figures the unconditional probabilities are indicated by cloud type to facilitate comparison between the two sets of statistics. The temporal persistence of cloud types will be discussed first for these stations; then the probability of one cloud type being followed by another will be presented briefly for Columbia, Missouri.

4.1.1 The Temporal Persistence of a Given Cloud Type

The synoptic character of Region 11's winter climate is clearly evident in the temporal statistics for Kansas City and Columbia (Figures 4-1 and 4-2). Convective clouds such as cumulus and cumulonimbus are not reported, and there is very little mention of nimbostratus or altostratus. This second set of cloud types is associated with warm fronts, but is rarely reported

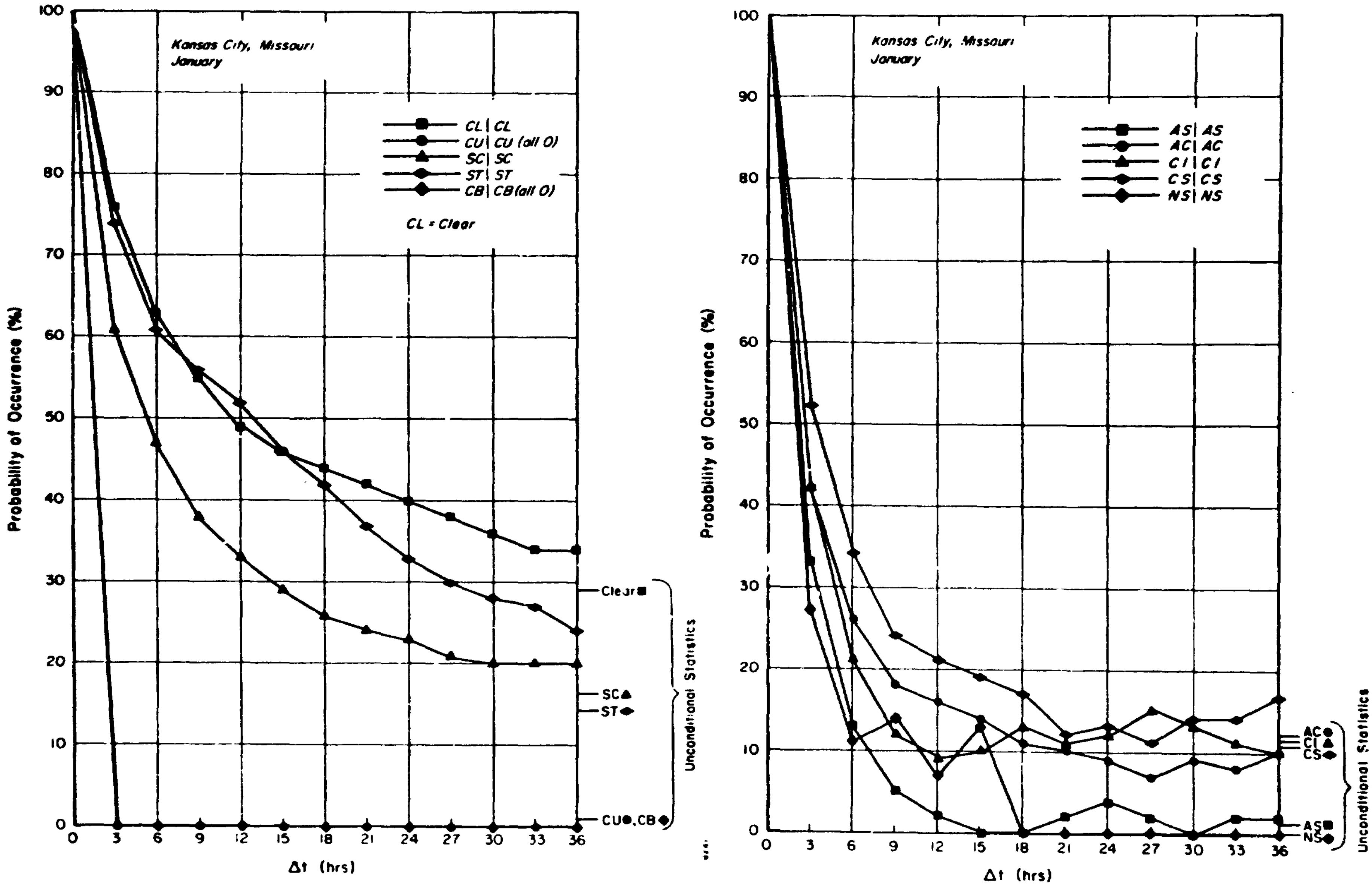


Figure 4-1 Temporal Statistics for Kansas City Missouri - January

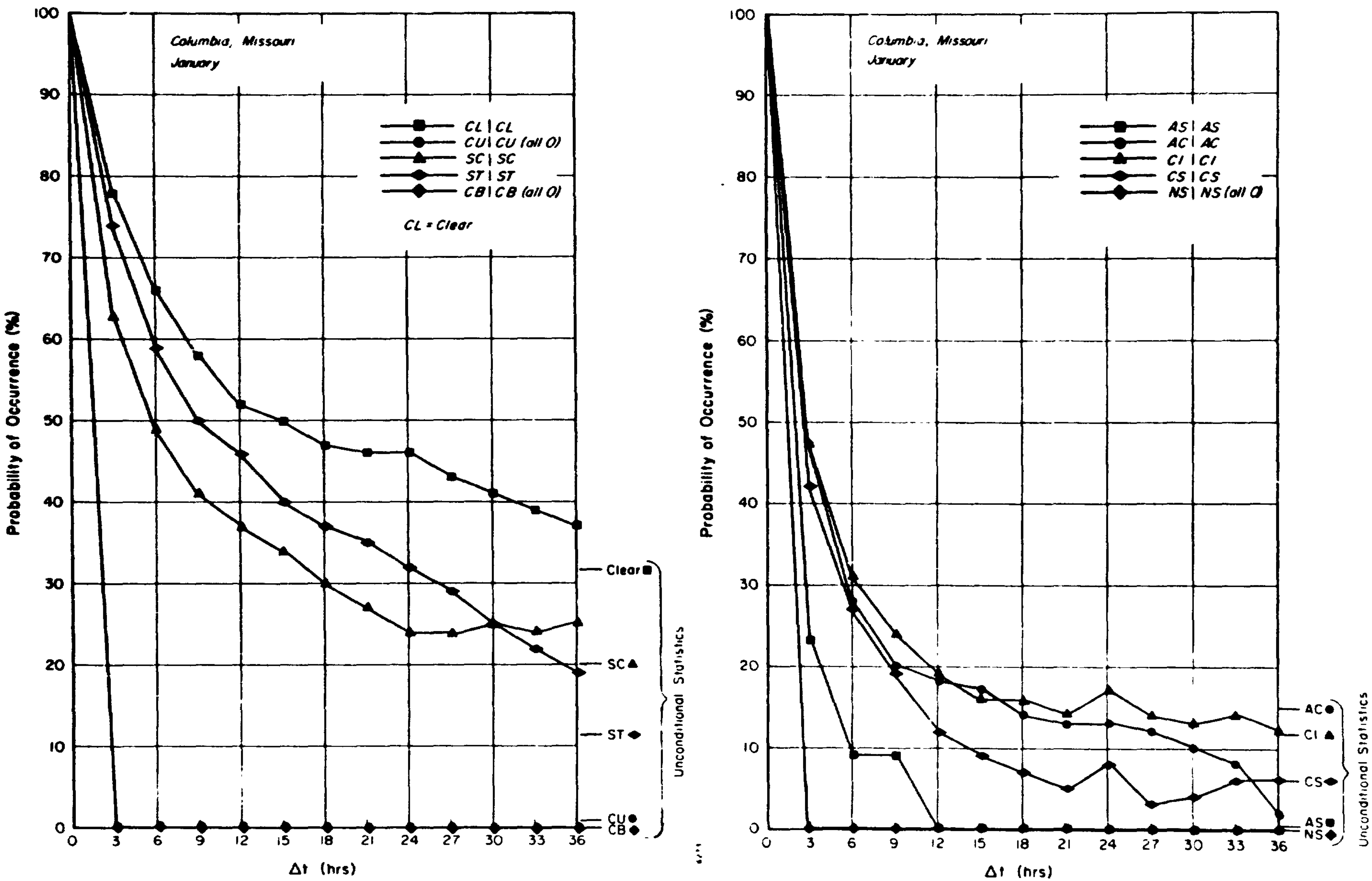


Figure 4-2 Temporal Statistics for Columbia, Missouri - January

in this region, possibly because of obscuration by lower cloud layers or precipitation. The stratiform clouds are much in evidence, though, and definitely show persistence. This persistence is the strongest for stratus, even after 36 hours the temporal conditional is still higher than the unconditional probability. Stratocumulus, like altocumulus, also shows some time dependence; however, this is almost gone after 12 hours and definitely after 18 hours.

The cirriform clouds show the same time persistence as the altocumulus and are often associated with the same weather conditions. However, these clouds do exhibit one very interesting feature in their temporal probabilities - a pronounced peak at $\Delta t = 24$ hours. No diurnal cycle is normally attributed to either cirrus or cirrostratus clouds; these clouds either remain fairly constant over a long period of time, or are associated with a frontal passage or warm air advection. Thus this temporal dependence is probably caused by observer bias rather than meteorological conditions.

Observations of cirrus during the daylight hours are often quite difficult if the cirrus does not contrast sufficiently with the blue sky behind it. Slight haze will also tend to obscure it, making its presence difficult to detect. At night, the clouds are too high, and often too thin, to be detected, and the naked eye, seeing the stars clearly, will often assume that no clouds are present. On the other hand, sunrise and sunset both tend to highlight these clouds; if they are present at dawn, they are almost invariably reported. (Low level cloudiness in the late afternoon tends to obscure cirrus at dusk.) Such biases in reporting would definitely favor a 24-hour time dependence.

In summer, the dominance of synoptic scale weather systems gives way to a mixture of mesoscale and convective cloud systems. Cumulus clouds reach a reporting frequency of 15%, and cumulonimbus account for another 5% of all cloud (and no cloud) observations. These cloud types have a pronounced diurnal character; due primarily to intensive daytime heating and to the resulting convective activity, they tend to occur mainly in the mid and late afternoon. Figures 4-3 and 4-4 show that there is a 30% probability of cumulus recurring at the same time one day after it has been reported. Thunderstorms also show a peak temporal conditionality at 24 hours; this is not as sharp as the peak for cumulus primarily because many cumulonimbus are associated with frontal systems. The same can be said for stratocumulus.

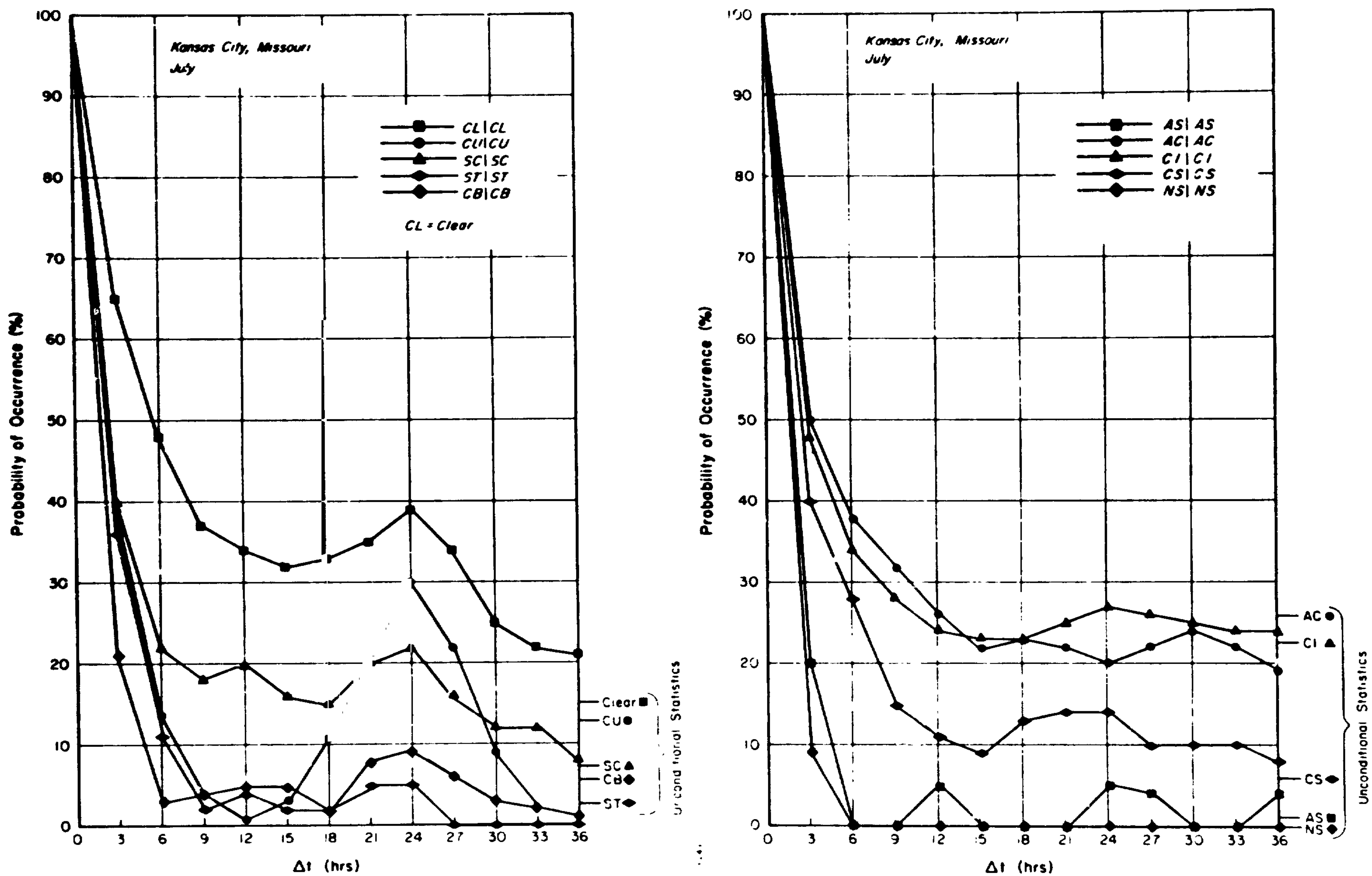


Figure 4-3 Temporal Statistics for Kansas City, Missouri - July

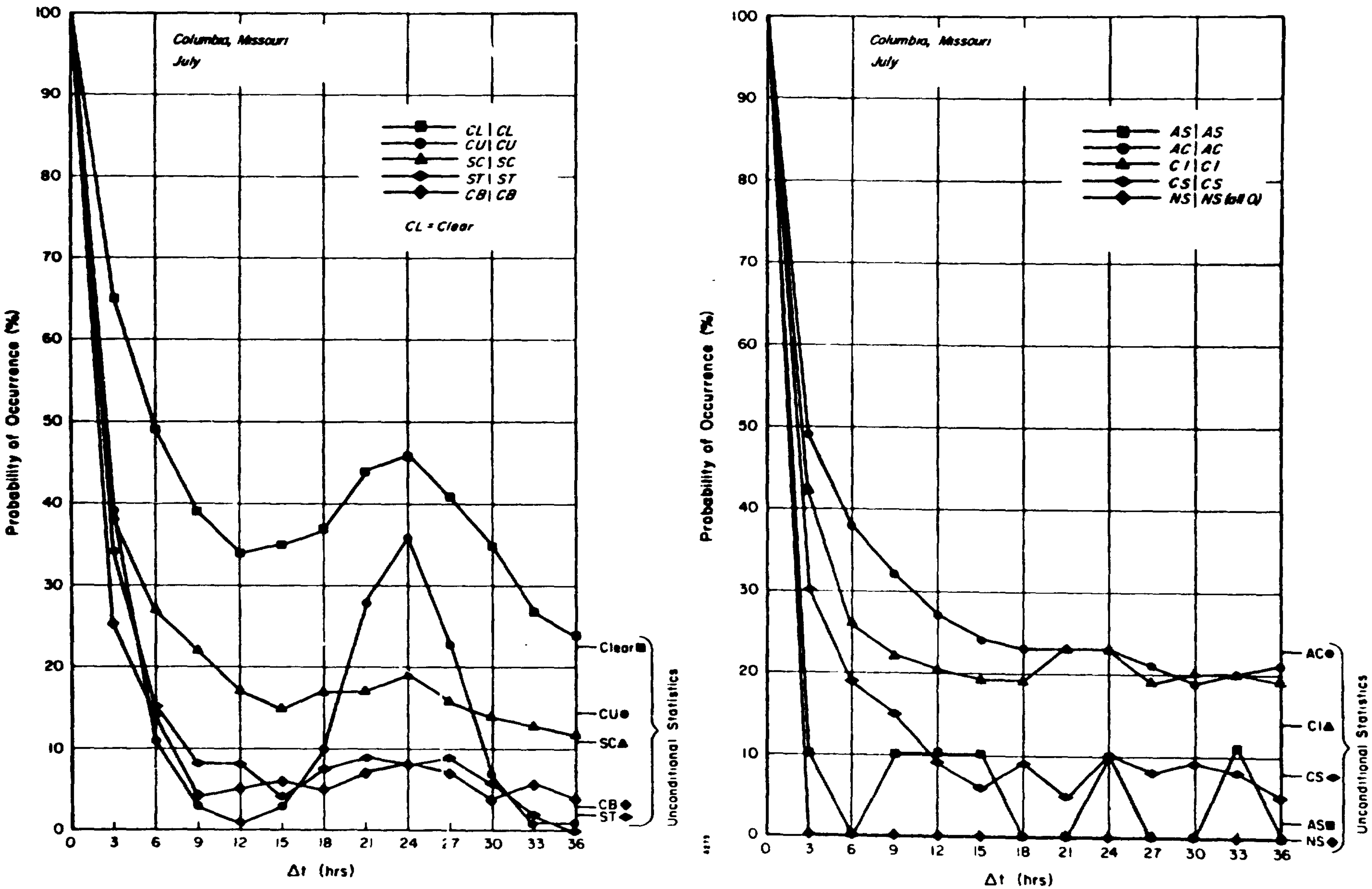


Figure 4-4   Temporal Statistics for Columbia, Missouri - July

A related diurnal cycle is seen in the clear sky statistics; the actual peak probability is definitely out of phase with the cumulus, but the temporal conditionality, being time independent, matches well.

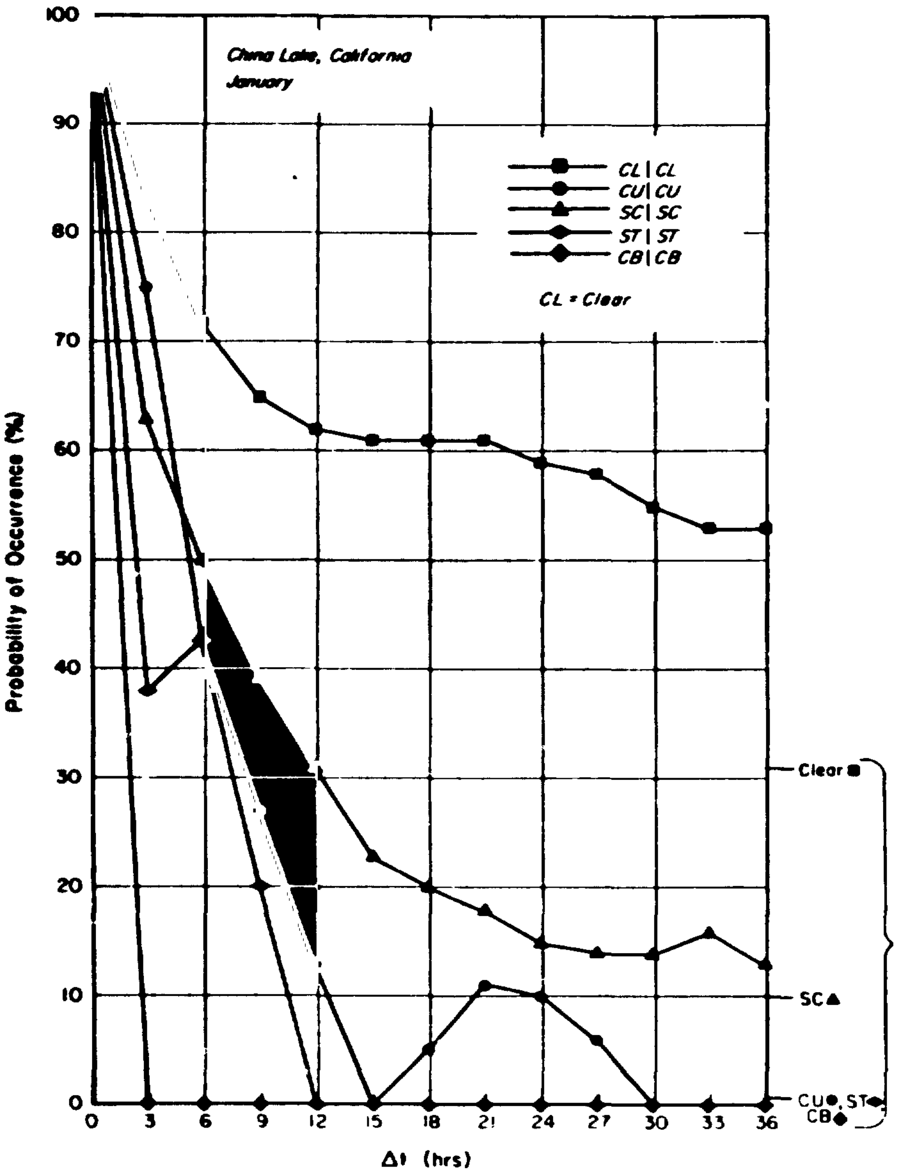
Little can be said about the temporal conditionality of the stratiform clouds (stratus, altostratus, and nimbostratus); they occur too infrequently to permit any kind of statistically valid study. The cirrus and cirriform clouds show little difference in their temporal dependence from the statistics seen for January; the discussion there would be applicable here.

The temporal conditionals for China Lake and Las Vegas will be discussed together as the similarities in cloud conditions between these two stations is too strong to justify separate analyses. High clouds are the most frequently reported cloud types in this area (e.g., altocumulus, cirrus, cirrostratus) and stratiform clouds are the rarest (e.g., stratus, altostratus, nimbostratus). Of course, clear skies dominate; even in January the probability of clear skies being reported 36 hours after a clear sky occurrence is still 50% (Figures 4-5 and 4-6).

In winter, the diurnal variation in cumulus is clearly seen, with a minimum at Δt = 24 hours. The temporal conditionality of stratocumulus seen in Region 11 is also found for these stations showing an asymptotic approach to its unconditional probability of occurrence after 18 hours. The conditionality of altocumulus decreases smoothly with time; in fact at 36 hours it is below the absolute probability, and seems to imply that an occurrence of altocumulus makes a recurrence unlikely within 1-1/2 days.

The previously discussed 24 hour correlation in cirrus is even more pronounced here. The reporting bias in cirrus is probably still a very important factor in this maximum; however, the diurnal cycle in cumulus may augment the dependence. These statistics were computed from predominant cloud types; if 45% cloud cover was cirrus for the entire day it would not necessarily be the major cloud type all the time. For example, it might be the only cloud type through the night and morning, only to be obscured by cumulus in the afternoon developing into 50% sky cover. It might then reappear as the predominant cloud type after the cessation of convective activity in the evening.

No noticeable maximum is seen in the cirrostratus; much of the occurrence of this cloud type in this area is caused by the proximity of the jet



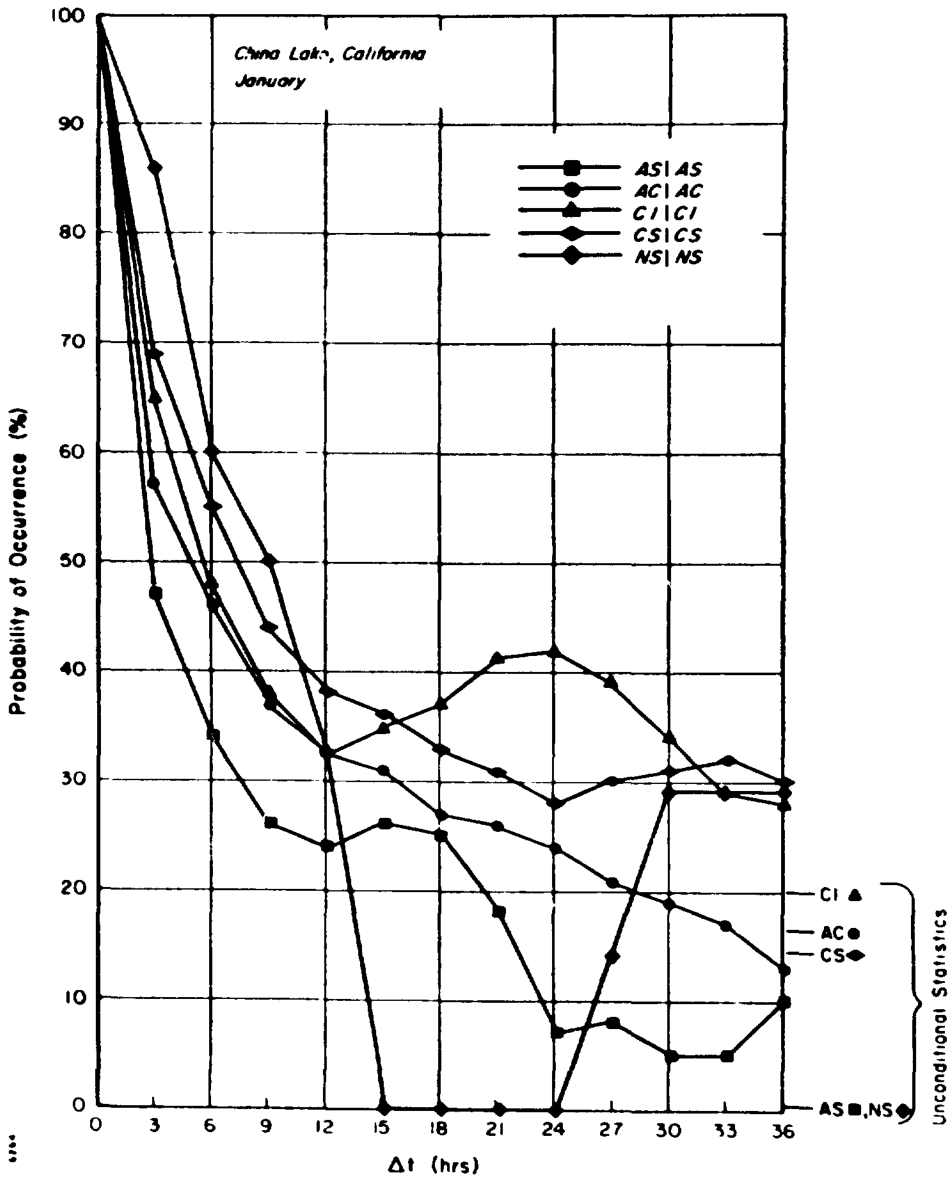


Figure 4-5 Temporal Statistics for China Lake, California - January

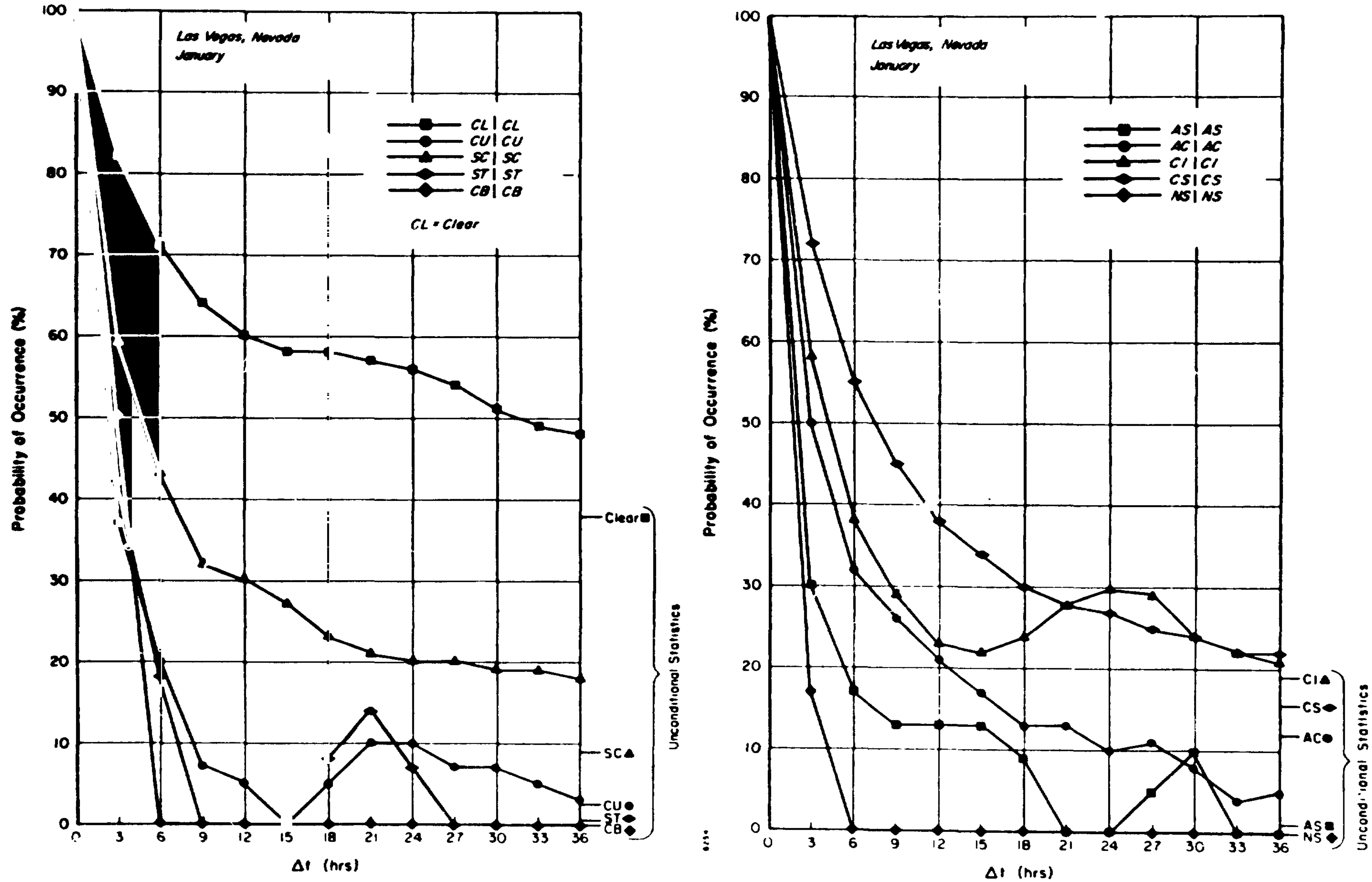


Figure 4-6 Temporal Statistics for Las Vegas, Nevada - January

stream. It may thus be denser and more clearly seen than the rarer cirrostratus in Region 11.

Summer in these regions is not associated with weather conditions substantially different from those found for winter. There is, of course, an increase in cumulus and cumulonimbus; there is also a significant drop in stratocumulus and cirrostratus. The diurnal character of the cumuliform clouds is even more obvious (Figures 4-7 and 4-8) than it is in January, and is now also evident in the infrequent reports of stratocumulus and cirrostratus. The major differences are in the temporal conditionalities of cirrus and altocumulus.

4.1.2 The Temporal Dependence of One Cloud Type Upon Another

The study of the sequence of cloud types and cloud formations is one of great interest to most real-time forecasters. Much has been written on the subject, discussing frontal passages characterized by high level, then middle level, then low level clouds, followed by clear skies, or analyzing convective activity leading to cumulus, then cumulus congestus, then cumulonimbus. It was not possible within the scope of this study to perform a detailed analysis of this interdependence; however, this section will present a few conditional probabilities for Columbia, Missouri, in July.

Three hours after a cloud type has been sighted as a predominant layer its probability of being seen again is still well above its unconditional probability, and, in general, is well above the conditional probability of seeing any other cloud type as the predominant layer. This high autocorrelation was seen quite clearly in the plots of the temporal conditionals (Figures 4-1 through 4-8), and shown here in Table 4-1.

There are, however, a few notable exceptions. The most obvious is the 42% probability of stratus being followed by stratocumulus three hours later (Figure 4-9). This exceeds the 38% probability of stratus remaining stratus for three hours and is probably caused by normal buildup found either in a developing front or in a zone undergoing rapid solar heating. Similar meteorological factors are reflected in the fact that altostratus has a 40% probability of

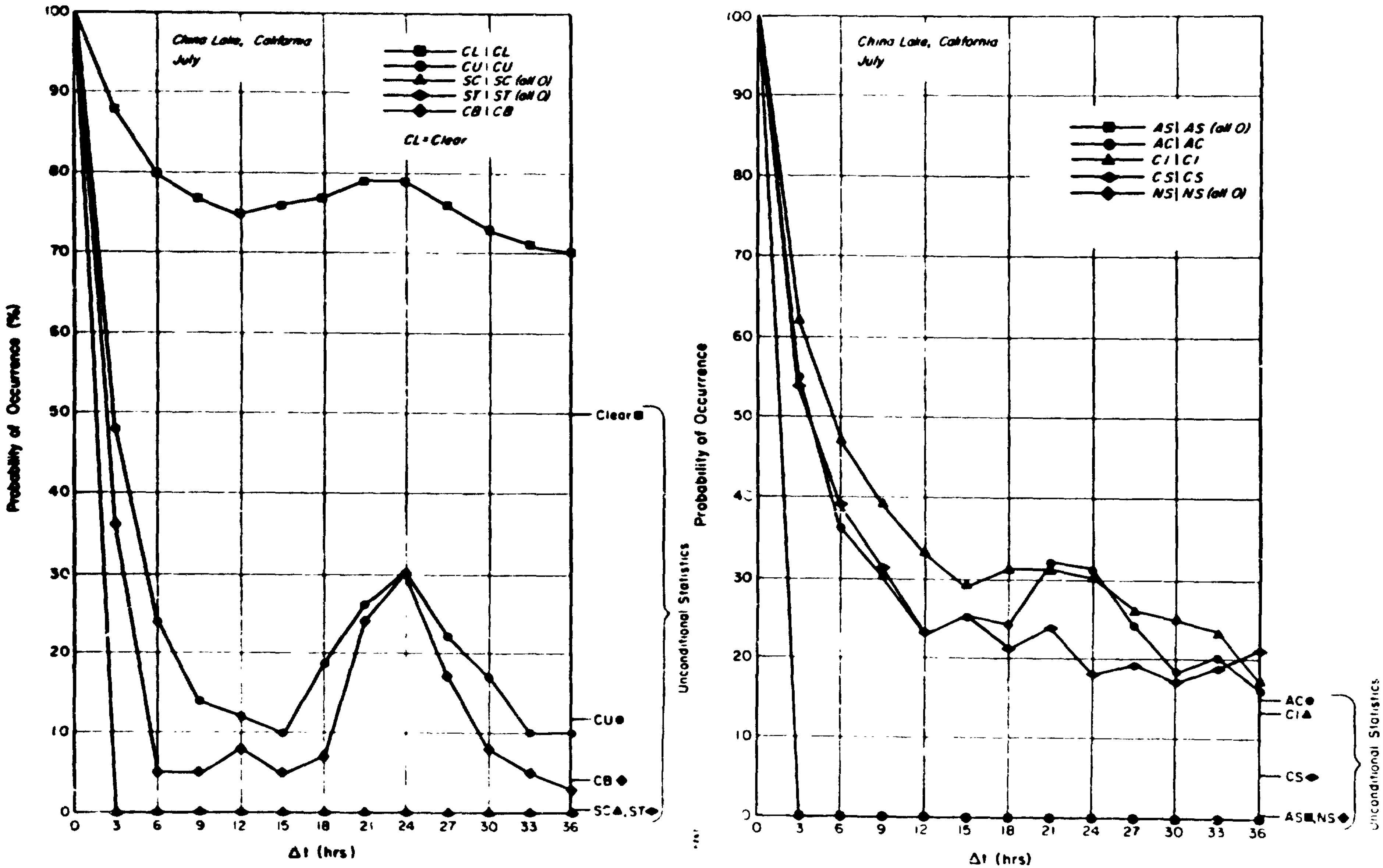


Figure 4-7 Temporal Statistics for China Lake, California - July

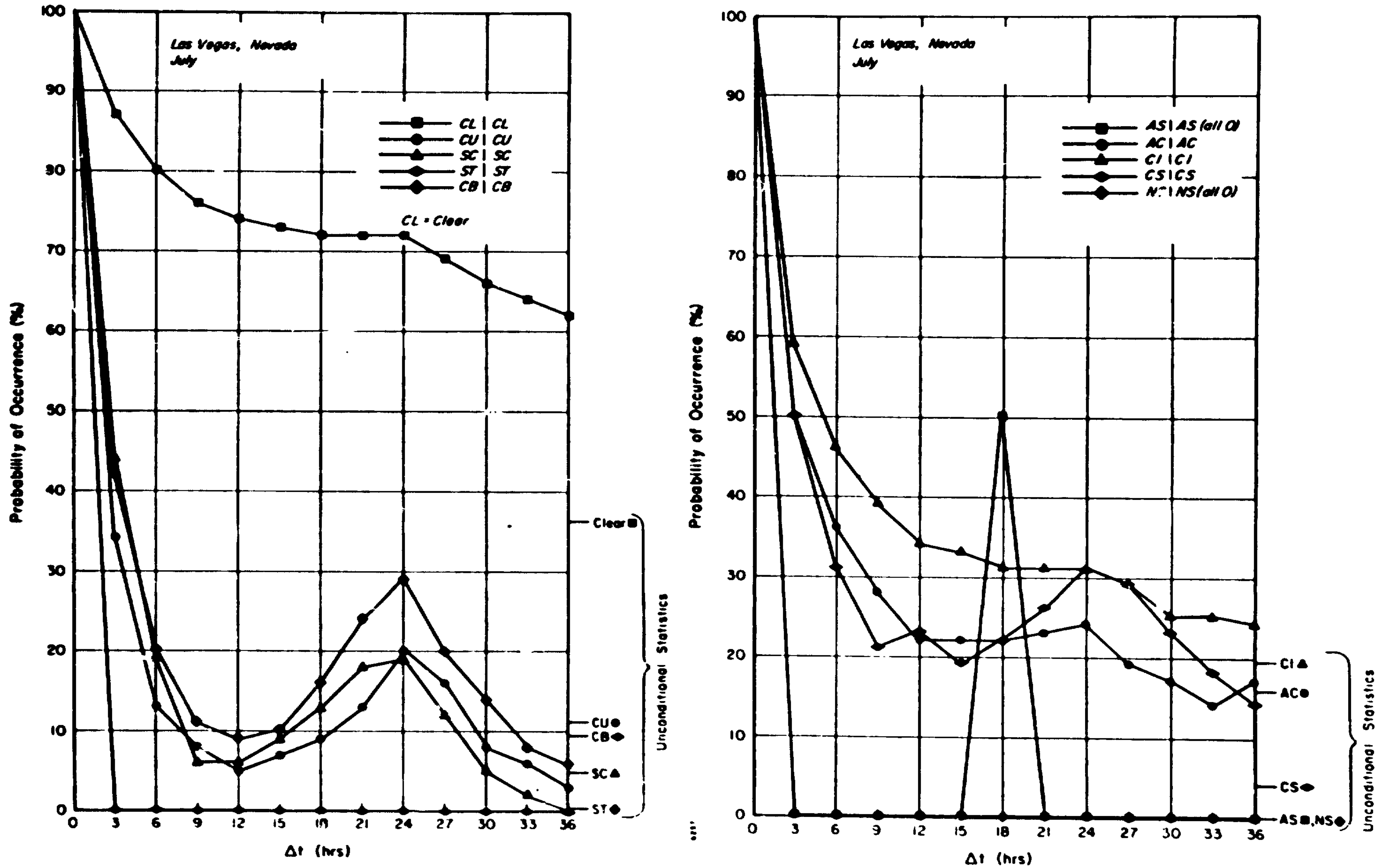


Figure 4-8 Tempora' Statistics for Las Vegas, Nevada - July

TABLE 4-1

TEMPORAL CONDITIONALS FOR COLUMBIA, MISSOURI IN JULY - Δt=3 HOURS

CONDITIONAL PROBABILITIES

TIME STEP = 3 HRS. COLUMBIA MISSOURI

MONTH 7 YEAR 58 THRU 67

	CL	CU	SC	ST	CB	AS	AC	CI	CS	NS	TOTAL
CL	477 0.65	52 0.07	24 0.03	2 0.00	6 0.01	0 0.0	49 0.07	102 0.14	19 0.03	0 0.0	731
CU	70 0.26	106 0.39	16 0.06	1 0.00	12 0.04	1 0.00	16 0.06	41 0.15	6 0.02	0 0.0	269
SC	21 0.09	27 0.11	92 0.38	15 0.06	10 0.04	0 0.0	45 0.19	22 0.09	7 0.03	0 0.0	239
ST	3 0.06	4 0.08	22 0.42	18 0.34	1 0.02	1 0.02	3 0.06	0 0.0	1 0.02	0 0.0	53
CB	3 0.04	5 0.07	6 0.08	4 0.05	18 0.25	0 0.0	21 0.29	5 0.07	11 0.15	0 0.0	73
AS	1 0.10	2 0.20	1 0.10	1 0.10	0 0.0	1 0.10	4 0.40	0 0.0	0 0.0	0 0.0	10
AC	54 0.12	26 0.06	50 0.11	6 0.01	12 0.03	2 0.00	224 0.49	53 0.12	32 0.07	0 0.0	459
CI	92 0.21	42 0.10	16 0.04	0 0.0	9 0.02	4 0.01	54 0.12	183 0.42	38 0.09	0 0.0	438
CS	14 0.09	6 0.04	11 0.07	2 0.01	5 0.03	1 0.01	44 0.27	31 0.19	49 0.30	0 0.0	163
NS	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0
											2435

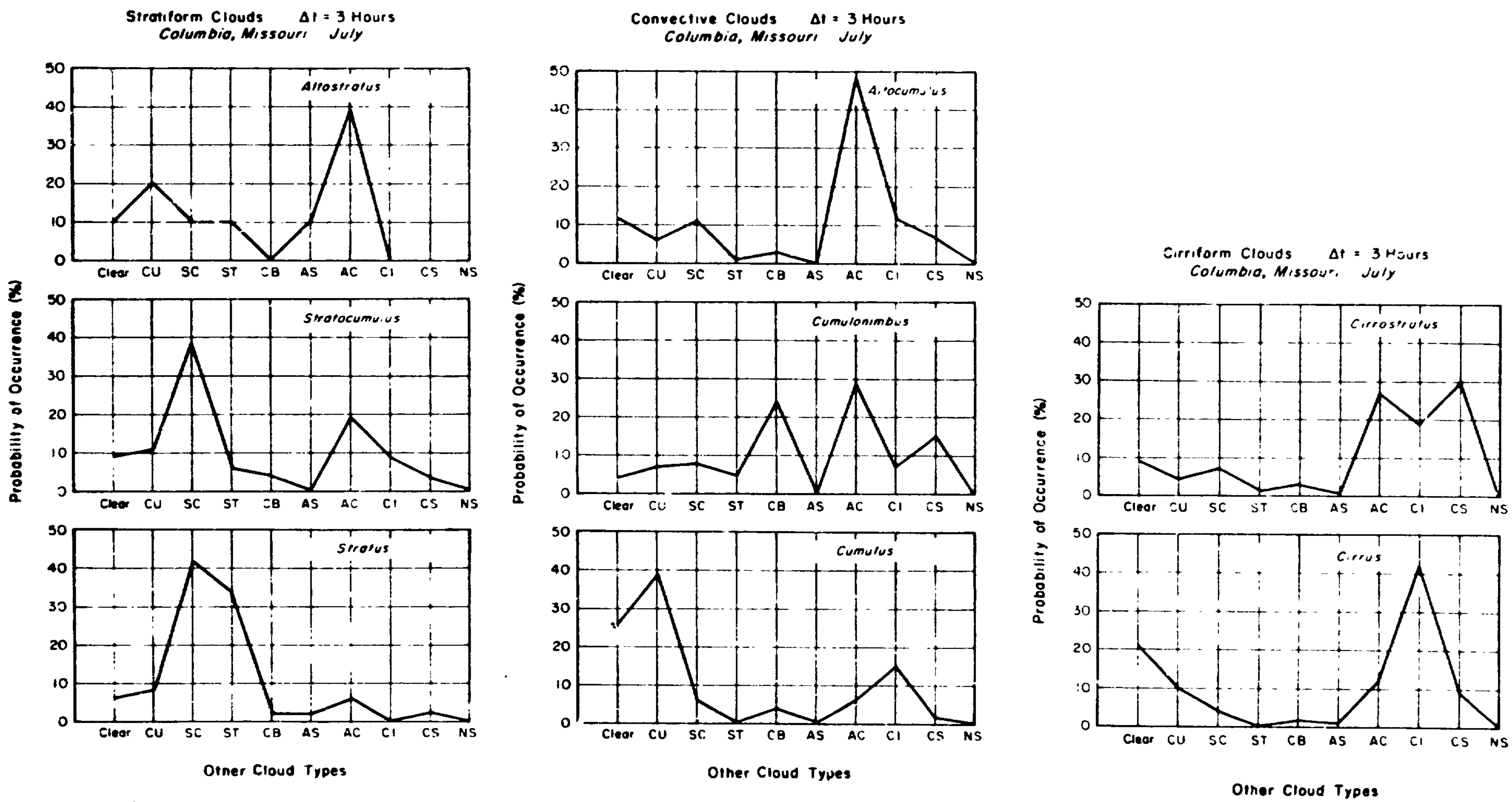


Figure 4-9 Selected Multi Cloud Temporal Conditionals for Columbia, Missouri in July - Δt = 3 hours

being followed by altocumulus. Neither stratus nor altostratus have high frequencies of occurrence here in the summer; there is a far greater likelihood of stratocumulus and altocumulus, perhaps because the first cloud types tend to rapidly become the second.

Frontal passages are clearly indicated in these statistics. Cirrostratus shows a 29% likelihood of remaining for three hours, but it shows almost as high a probability of being replaced by altocumulus, and a significant probability of fading into cirrus. Altocumulus shows a much greater persistence; it has a 50% probability of remaining just that over a three hour time period.

In Missouri, many thunderstorms are associated with frontal systems; first occurring along the edge of the front and then building up and outrunning it. These statistics show this relationship quite clearly; if cumulonimbus is given as the predominant cloud type, there is a 29% probability that altocumulus will be the predominant cloud three hours later, and a 15% probability that cirrostratus will follow. The persistence of severe storm systems is also evident; there is a 25% probability of cumulonimbus being followed by cumulonimbus.

Convective activity is also important in July as is illustrated by the 20% probability of stratocumulus becoming altocumulus, and the 40% likelihood of cumulus remaining cumulus. The rapid cessation of convective activity associated with sundown is also seen as cumulus has a 26% probability of giving way to totally clear skies, and a 15% probability of giving way to cirrus after three hours.

After six hours the probability of a cloud type being reported again is considerably less (Table 4-2). There is now a 43% likelihood of clear skies where originally cumulus dominated and only altocumulus shows more than a 30% probability of remaining unchanged. The tendency for altocumulus to replace cirrostratus in a frontal passage, and for convective activity to build altocumulus is clearly illustrated here. No cloud type has less than a 10% probability of being followed by altocumulus at six hours and cumulonimbus, cirrostratus, and altostratus all show at least 25% probability of becoming, or being replaced by, altocumulus (Figure 4-10). This is impressive, especially since altocumulus has an unconditional probability of 19%.

Similar meteorological conditions are seen in the conditionality leading to stratocumulus; at this time the higher clouds in a front are giving way

TABLE 4-2

TEMPORAL CONDITIONALS FOR COLUMBIA, MISSOURI IN JULY - Δt=6 HOURS

CONDITIONAL PROBABILITIES

TIME STEP = 6 HRS, COLUMBIA MISSOURI

MONTH 7 YEAR 58 THRU 67

	CL	CU	SC	ST	CB	AS	AC	CI	CS	NS	TOTAL
CL	355	83	28	6	8	1	72	145	30	0	728
	0,49	0,11	0,04	0,01	0,01	0.00	0,10	0,20	0,04	0,0	
CU	119	30	20	1	13	0	29	46	11	0	269
	0,44	0,11	0,07	0,00	0,05	0,0	0,11	0,17	0,04	0,0	
SC	36	38	65	13	9	0	43	25	8	0	237
	0,15	0,16	0,27	0,05	0,04	0,0	0,18	0,11	0,03	0,0	
ST	3	11	18	8	0	0	8	3	2	0	53
	0,06	0,21	0,34	0,15	0,0	0,0	0,15	0,06	0,04	0,0	
CB	7	3	14	3	10	0	18	6	12	0	73
	0,10	0,04	0,19	0,04	0,14	0,0	0,25	0,08	0,16	0,0	
AS	0	1	2	1	0	0	4	1	1	0	10
	0,0	0,10	0,20	0,10	0,0	0,0	0,40	0,10	0,10	0,0	
AC	65	32	66	11	17	5	171	60	27	0	454
	0,14	0,07	0,15	0,02	0,04	0,01	0,38	0,13	0,06	0,0	
CI	123	59	16	3	13	3	63	113	42	0	435
	0,28	0,14	0,04	0,01	0,03	0,01	0,14	0,26	0,10	0,0	
CS	19	9	6	4	2	1	52	40	31	0	164
	0,12	0,05	0,04	0,02	0,01	0,01	0,32	0,24	0,19	0,0	
NS	0	0	0	0	0	0	0	0	0	0	0
	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	
											2423

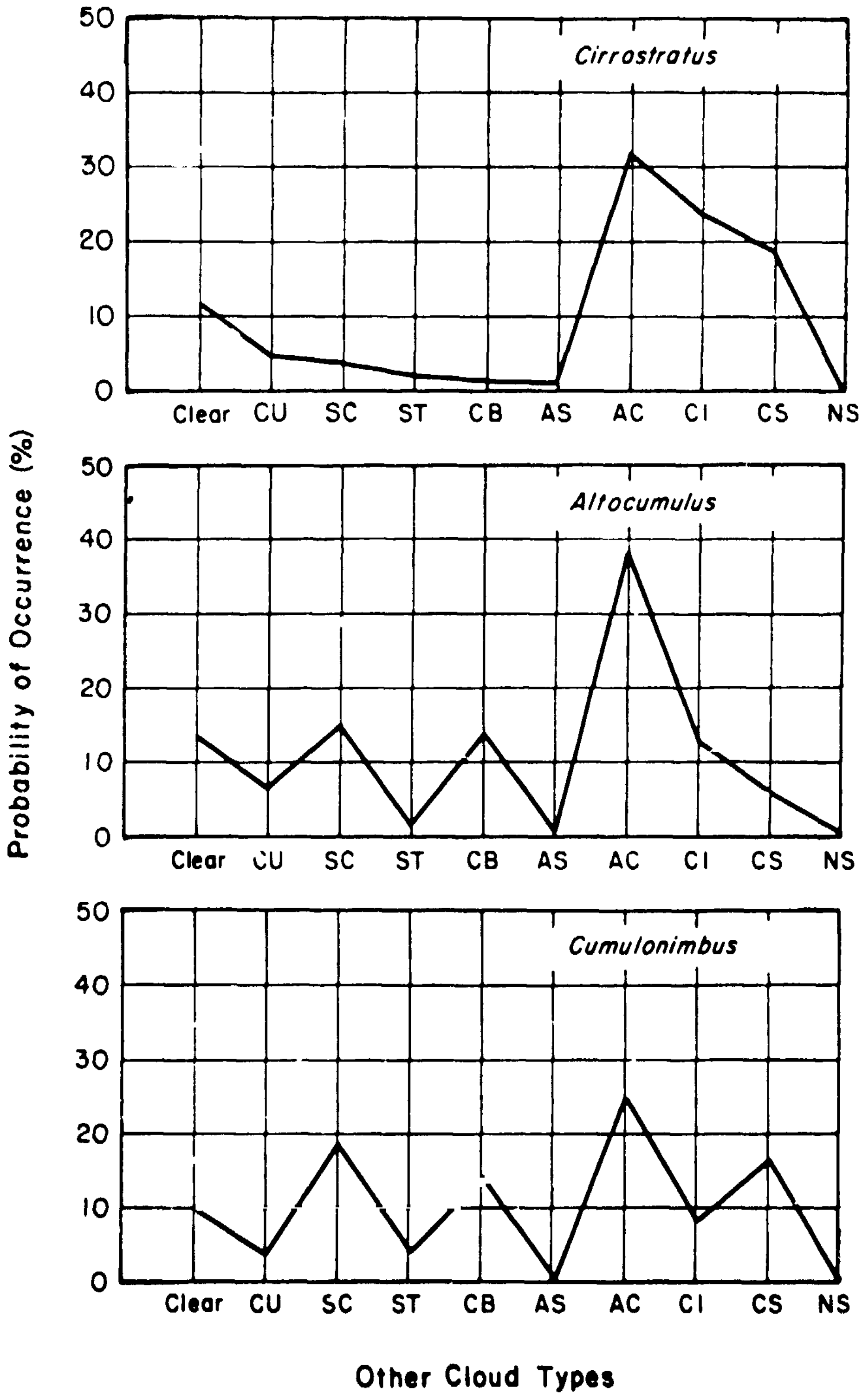


Figure 4-10 Selected Multi Cloud Temporal Conditionals for Columbia, Missouri in July - Δt = 6 hours

to the lower clouds. A slight increase in the probability of clear skies is also seen for most cloud types, yet it is not large enough in most cases to be significant.

As was indicated in the previous section, the passage of twelve hours allows most cloud temporal conditionals to revert to near their unconditional values. This is supported by the statistics on cloud interdependence (Table 4-3), however, some biases are evident. With the exception of the clear, cumulus, and cirrus categories, the conditional probability of clear skies is still below the unconditional. The conditional probability of various cloud types (except cirrus) being replaced by cirrus is also low; on the other hand stratocumulus still shows conditional probabilities greater than its unconditional value. The same is true for altocumulus (Figure 4-11).

Examination of the data shows that the bias towards stratocumulus and altocumulus again reflects the combined effects of frontal passages and convective activity. On the other hand, the low conditionals for the clear and cirrus conditions, both background sky reports, indicates that cloudiness in some form or other is apt to persist for twelve hours.

With certain exceptions, the twenty-four hour mixed cloud conditional probabilities (Table 4-4) are the same as the unconditional probabilities (Figure 4-2). The high probability of cumulus being followed by cumulus was discussed in the previous section, and the above comments on stratocumulus and altocumulus are still relatively appropriate. However, it is clear that for July in Missouri, after 24 hours, there is little temporal conditionality.

4.2 Spatial Conditional Probability

In planning satellite mission simulation it is important to know the temporal conditionality of cloud types to determine the expected cloud conditions on subsequent passes. Likewise it is important to have information on the spatial conditionality of cloud systems to determine the expected cloud conditions in adjacent locations. Stations located 50 miles apart would often be expected to have similar weather conditions; on the other hand, stations located 200 miles apart might frequently be under totally different air masses. Greaves et al (1971) investigated this conditionality in light of cloud cover amounts; this section will further this analysis in light of the cloud type data .

TABLE 4-3

TEMPORAL CONDITIONALS FOR COLUMBIA, MISSOURI IN JULY - Δt=12 HOURS

CONDITIONAL PROBABILITIES

TIME STEP = 12 HRS, COLUMBIA MISSOURI

MONTH 7 YEAR 58 THRU 67

	CL	CU	SC	ST	CB	AS	AC	CI	CS	NS	TOTAL
CL	247 0.34	121 0.17	35 0.05	1 0.00	12 0.02	0 0.0	100 0.14	167 0.23	42 0.06	0 0.0	725
CU	125 0.48	2 0.01	24 0.09	4 0.02	11 0.04	1 0.00	37 0.14	38 0.15	20 0.08	0 0.0	262
SC	52 0.22	29 0.13	39 0.17	10 0.04	14 0.06	1 0.00	46 0.20	32 0.14	9 0.04	0 0.0	232
ST	10 0.19	9 0.17	11 0.21	4 0.08	1 0.02	0 0.0	11 0.21	4 0.08	3 0.06	0 0.0	53
CB	7 0.10	12 0.16	15 0.21	4 0.05	1 0.01	0 0.0	17 0.23	11 0.15	6 0.08	0 0.0	73
AS	1 0.10	0 0.0	2 0.20	0 0.0	0 0.0	1 0.10	5 0.50	0 0.0	1 0.10	0 0.0	10
AC	91 0.20	53 0.12	64 0.14	14 0.03	13 0.03	3 0.01	125 0.27	68 0.15	28 0.06	0 0.0	459
CI	151 0.35	27 0.06	25 0.06	7 0.02	13 0.03	3 0.01	76 0.18	87 0.20	39 0.09	0 0.0	428
CS	35 0.22	12 0.07	16 0.10	5 0.03	7 0.04	1 0.01	41 0.26	28 0.17	15 0.09	0 0.0	160
NS	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0
											2402

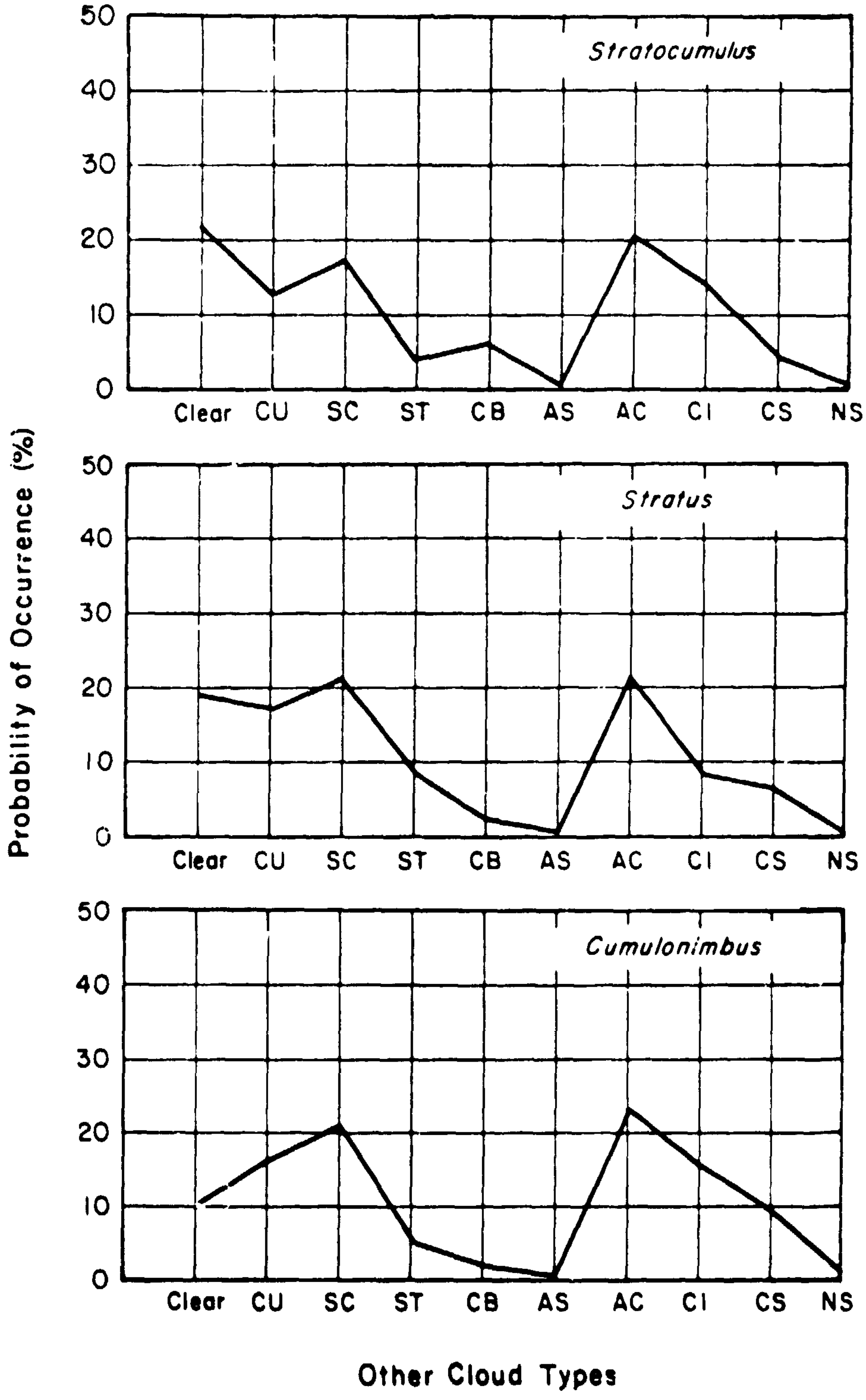


Figure 4-11 Selected Multi Cloud Temporal Conditionals for Columbia, Missouri in July - Δt = 12 hours

TABLE 4-4

TEMPORAL CONDITIONALS FOR COLUMBIA, MISSOURI IN JULY - Δt=24 HOURS

CONDITIONAL PROBABILITIES

TIME STEP = 24 HRS. COLUMBIA MISSOURI

MONTH 7 YEAR 58 THRU 67

	CL	CU	SC	ST	CB	AS	AC	CI	CS	NS	TOTAL
CL	327 0,46	33 0,05	40 0,06	1 0,00	19 0,03	1 0,00	113 0,16	124 0,18	50 0,07	0 0,0	708
CU	34 0,13	94 0,36	18 0,07	2 0,01	7 0,03	1 0,00	36 0,14	51 0,19	19 0,07	0 0,0	262
SC	70 0,30	23 0,10	43 0,19	7 0,03	9 0,04	1 0,00	43 0,19	30 0,13	5 0,02	0 0,0	231
ST	14 0,26	5 0,09	11 0,21	4 0,08	1 0,02	1 0,02	7 0,13	7 0,13	3 0,06	0 0,0	53
CB	23 0,32	9 0,13	10 0,14	3 0,04	6 0,08	1 0,01	10 0,14	9 0,13	1 0,01	0 0,0	72
AS	3 0,30	2 0,20	2 0,20	0 0,0	0 0,0	1 0,10	1 0,10	0 0,0	1 0,10	0 0,0	10
AC	112 0,25	42 0,09	46 0,10	17 0,04	12 0,03	3 0,01	105 0,23	84 0,19	30 0,07	0 0,0	451
CI	102 0,24	46 0,11	34 0,08	5 0,01	10 0,02	1 0,00	91 0,22	97 0,23	34 0,08	0 0,0	420
CS	29 0,18	9 0,06	23 0,15	10 0,06	7 0,04	0 0,0	44 0,28	19 0,12	16 0,10	0 0,0	157
NS	0 0,0	0 0,0	0 0,0	0 0,0	0 0,0	0 0,0	0 0,0	0 0,0	0 0,0	0 0,0	0
											2364

The logic used to derive the spatial conditional probabilities paralleled that used to derive the temporal conditions (Section 4.1). In this case, a computer program was written which, given a predominant cloud type C_i, at an "anchor" station, Station A, computes the probability of finding a cloud type C_j at the same time at a neighboring station, Station B. The joint occurrences of C_i and C_j were summed across all reporting times (k = 1,4,7...21 LST) over an entire 10-year period. The resulting sum S_{ij} was then divided by the sum of all cloud types C_j occurring with a given cloud type C_i to determine the spatial conditionality $P_{(j|i)}$, or

$$P_{(j|i)} = \frac{S_{ij}}{\sum_{j=0}^{9} S_{ij}}. \qquad (4\text{-}2)$$

Table 4-5 summarizes the five stations for which these conditionals were computed. January and July have again been selected for emphasis, and the analysis will concentrate on the spatial persistence of a given cloud type, $P_{(j|i)}$. For the reader's information, Appendix B will present all the spatial conditional probabilities computed for the given stations. It was not possible within the scope of this study to investigate the spatial interdependence of the various cloud types; however, as many of the results are quite interesting, the data is included for future reference.

4.2.1 Kansas City - Columbia - Belleville

These three stations (Kansas City - Columbia - Belleville) span the width of Missouri and are sequentially affected by the same frontal systems as storms move eastward across the state. the similarity in the unconditional cloud type statistics was seen in Section 3.1.1; thus the conditional statistics given here should provide a fairly accurate demonstration of west-east spatial conditionality. Beside the plots given for the spatial conditionals, the unconditionals representing Region 11 are given; this permits a ready evaluation of the spatial dependence.

TABLE 4-5

STATIONS SELECTED FOR SPATIAL ANALYSIS

"Anchor" Station A	Station B	Direction	Distance (N. Mi.)
Kansas City, Mo.	Columbia, Mo.	W-E	102.7
Kansas City, Mo.	Belleville, Ill.	W-E	225.0
Belleville, Ill.	Peoria, Ill.	S-N	127.6
Belleville, Ill.	Chicago, Ill.	SW-NE	216.2
China Lake, Calif.	Las Vegas, Nev.	SW-NE	120.1

A brief glance at Figure 4-12 confirms the hypothesis that the likelihood of the same cloud types decreases with distance. The only notable exception to this is cirrostratus, and this may be discounted on the grounds that Belleville has an anomalously high reporting frequency of this cloud type, and an anomalously low frequency of cirrus. (Altostratus occurs too rarely to generate statistically significant results.) It is also evident that some cloud types exhibit a far greater spatial persistence than do others. In January there is very little decrease in the conditional probability of clear skies or stratocumulus from Columbia to Belleville; both of these sky conditions, when they occur, tend to occur over a very large area, the former in conjunction with an anticyclone, the latter in connection with a large-scale shallow storm system. They are also the most frequently occurring conditions in this season; combined, the two types account for 55% of all reports.

Stratus is another cloud type showing considerable spatial coverage. Although its unconditional probability at Belleville is only 13%, its probability is increased to 37% when it is known that stratus is present in Kansas City. A similar dependence is seen in the cirrostratus, although its conditional probability at Belleville is only 0.15 above its unconditional. On the other hand, altocumulus and cirrus show a very high spatial dependence at 100 n.mi. but revert to their unconditional values at 225 n.mi. indicating that the clouds associated with frontal systems might not extend more than 200 n.mi. in a west-east direction.

July shows slightly less of a spatial dependence. The clear skies still show the highest conditionality, running 0.40 above the unconditional value at 100 n.mi. and 0.30 above the unconditional at 255 n.mi. These differences are almost identical to the winter values. Most of the other cloud types, however, show not only a lower conditional probability at 100 n.mi., but also less of an increase over the unconditional probabilities. At 225 n.mi., virtually all cloud types are within 0.05 of their unconditional values for this season.

The chief exceptions to the above statement are the cumulus and cumulonimbus clouds. These could not be investigated in the winter because of their rare occurrence during that season. Here it is seen that they show a definite spatial persistence. This would not be expected of an individual cumulus cloud, or of a thunderstorm, both of which tend to be

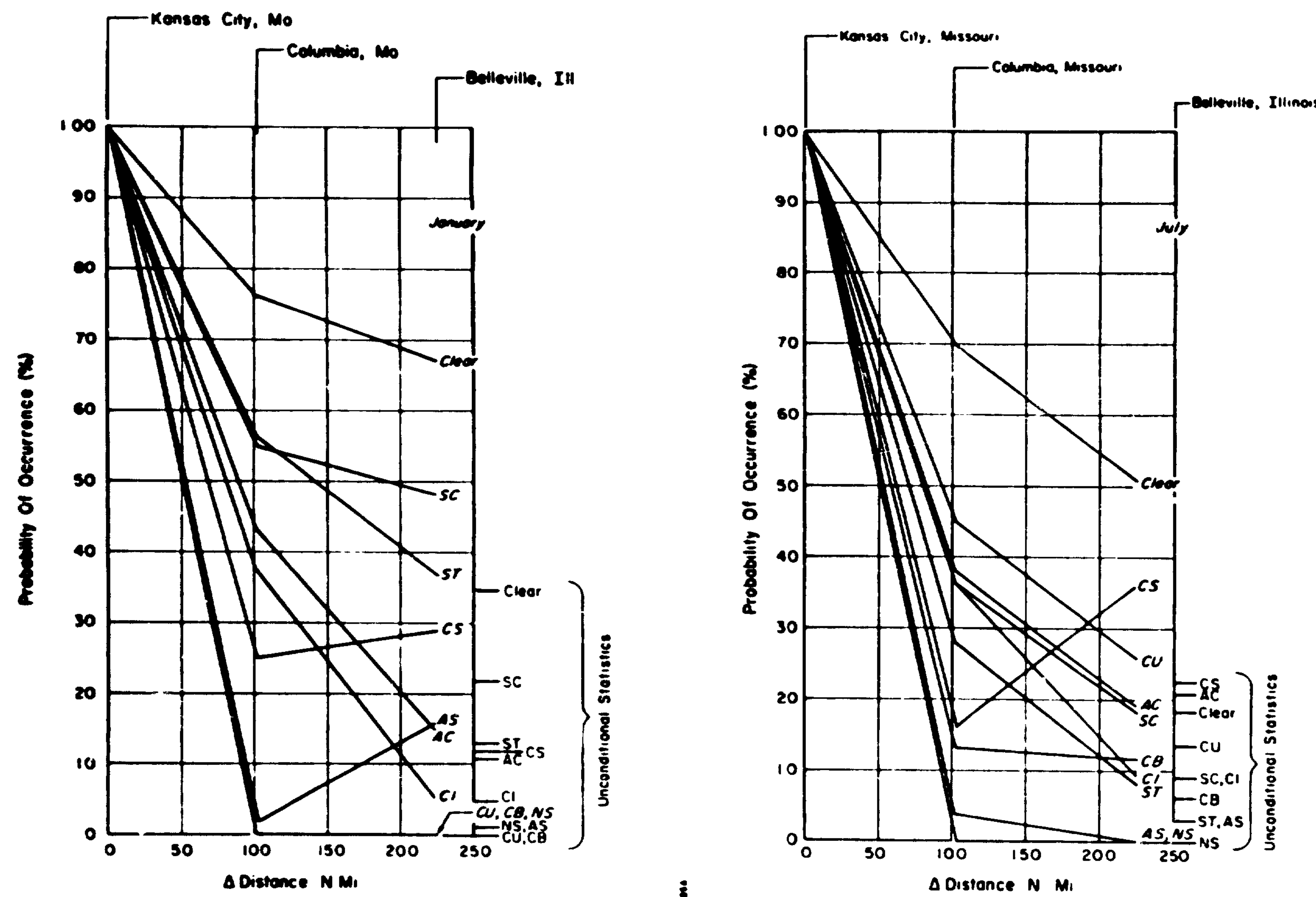


Figure 4-12 Spatial Conditionals for Kansas City, Missouri - Columbia Missouri - Belleville, Illinois

very localized; however, the cloud types presented here are predominant cloud types and are analyzed as such. The meteorological conditions which generate considerable convective activity - hot, clear, humid skies - tend to occur over a wide area. Thus the fact that the spatial conditional probability at 100 n.mi. is over 0.30 above the unconditional, and at 225 n.mi. is still over 0.10 above the unconditional, indicates that a high amount of cumulus in one location indicates a high amount of cumulus over a large region. Cumulonimbus is much more localized, yet it is clear that widespread convective activity influences its spatial extent.

4.2.2 Belleville - Peoria - Chicago

To provide a clear contrast between the west-east spatial distribution of cloud types, and the south-north spatial distribution of cloud types, these Illinois stations were selected on an axis almost perpendicular to that of the Missouri stations just analyzed. Belleville provides the intersection of these axes and is thus included in both sections. The analysis of the homogeneity of Region 11 established the similarity of Peoria and Chicago to Kansas City and Columbia; this section can thus examine directional biases in the spatial conditionality.

The January spatial conditionals for 100 n.mi. show a spatial dependence in the south-north direction which is at least equal to that found in the west-east direction (Figure 4-13). In fact, many of the conditional probabilities given for Belleville-Peoria match those given for Kansas City-Columbia, although the distance between the first two stations is 125 n.mi. rather than 100 n.mi. Conditional statistics are available in both data sets for 225 n.mi.; these are generally higher in the south-north direction. This corresponds well to the longitudinal orientation of most frontal systems and to the circular nature of many storm systems.

There are a few exceptions to the above statement. In January the spatial dependence of clear skies is much less in the north-south direction at 225 n.mi. (0.51 vs 0.67). This may be due to the localized effect of Lake Michigan on Chicago causing cloudiness when most of the Midwest is clear, rather than to a general pattern of clear skies. Cirrostratus again seems anomalous in both seasons; however, because of Belleville, these statistics are not reliable. A drop in the July spatial dependence is

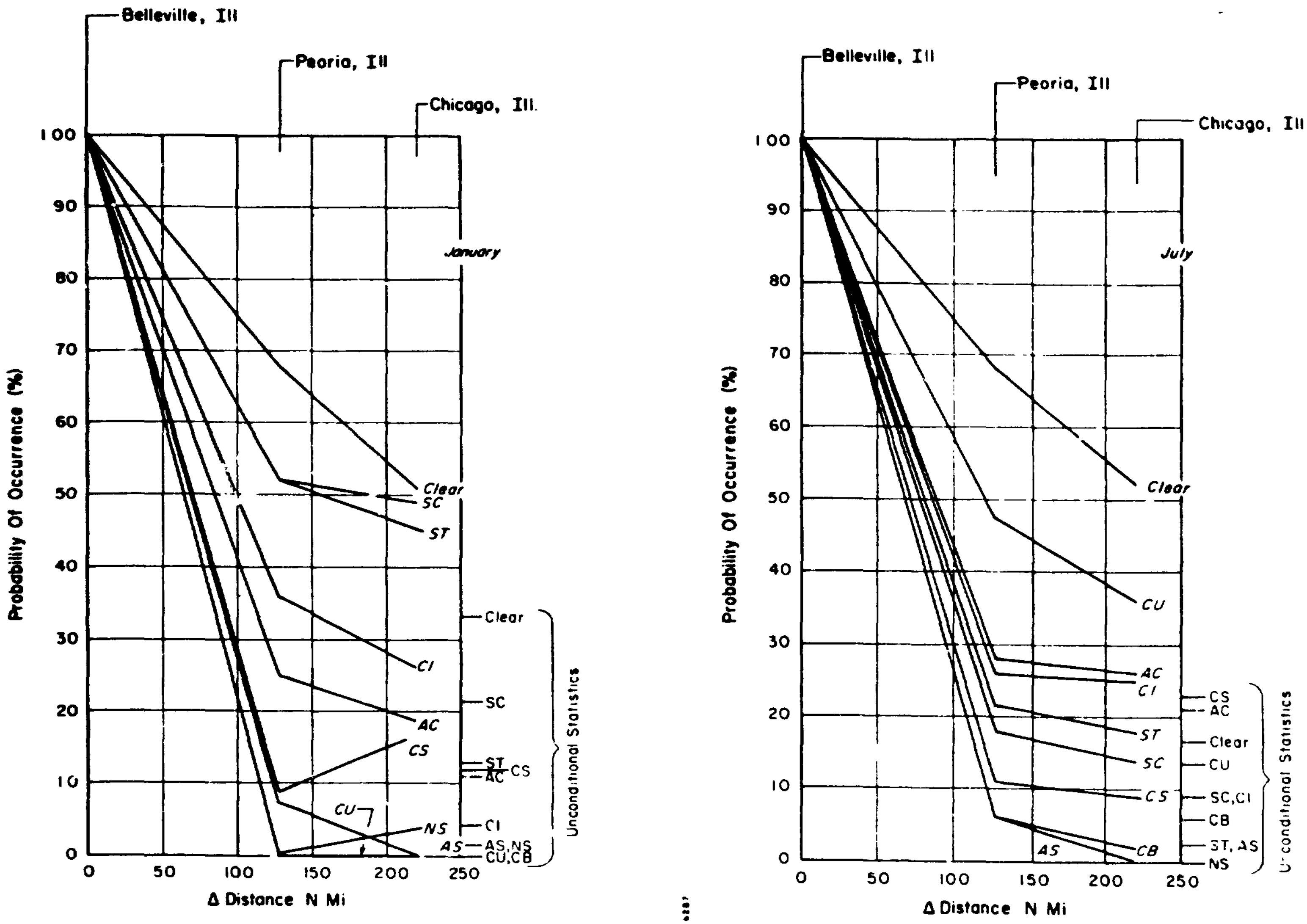


Figure 4-13 Spatial Conditionals for Belleville, Illinois - Peoria, Illinois - Chicago, Illinois

also seen for stratocumulus and cumulonimbus in the northward direction beyond 100 n.mi. Both of these cloud types are at their unconditional values at 225 n.mi. showing that these clouds may be latitudinally oriented in the summer.

4.2.3 China Lake - Las Vegas

Spatial conditional probabilities for these two stations are presented in Figure 4-14. The similarity in their unconditional statistics was previously established; their spatial conditionals, showing a southwest-northeast dependence are given here for comparison with Region 11's statistics.

Significant differences in the conditionalities are seen; for example, although Columbia, Missouri, and Las Vegas, Nevada, have almost identical probabilities of cumulus in July, the spatial conditional for Columbia, given cumulus in Kansas City, is much higher than that for Las Vegas given cumulus above China Lake (0.45 vs. 0.21).

Some of these differences are clearly due to the difference in climates between the Midwest and Southwest; the occurrence of synoptic scale systems is far rarer in the Southwest. Other differences are probably due to orographic effects; between China Lake and Las Vegas lie Death Valley and the Spring Mountains. This would definitely reduce the spatial dependence of the lower level cloud types which normally extend across a large area; it would not, of course, significantly influence the extent of cirriform clouds or the spatial dependence of clear skies.

Since these desert stations showed a greater similarity in their unconditional statistics than did most of the very homogeneous Region 11 stations, one must assume that large climatic differences do not occur. However, the high frequency of thunderstorms in Las Vegas, caused by the proximity of the mountain range, and the general alteration of cloud types due to varying surface elevations between the stations, clearly illustrate the dangers of applying spatial conditionals without an examination of possible orographic effects.

4.3 Diurnal Variability in the Number of Cloud Layers

Previous discussions have analyzed cloud types as though only one cloud layer was present at any time, the predominant cloud layer. This, of course, simplifies the presentation of temporal and spatial conditionals. It ignores, however, the frequency with which two or more cloud layers are observed. This

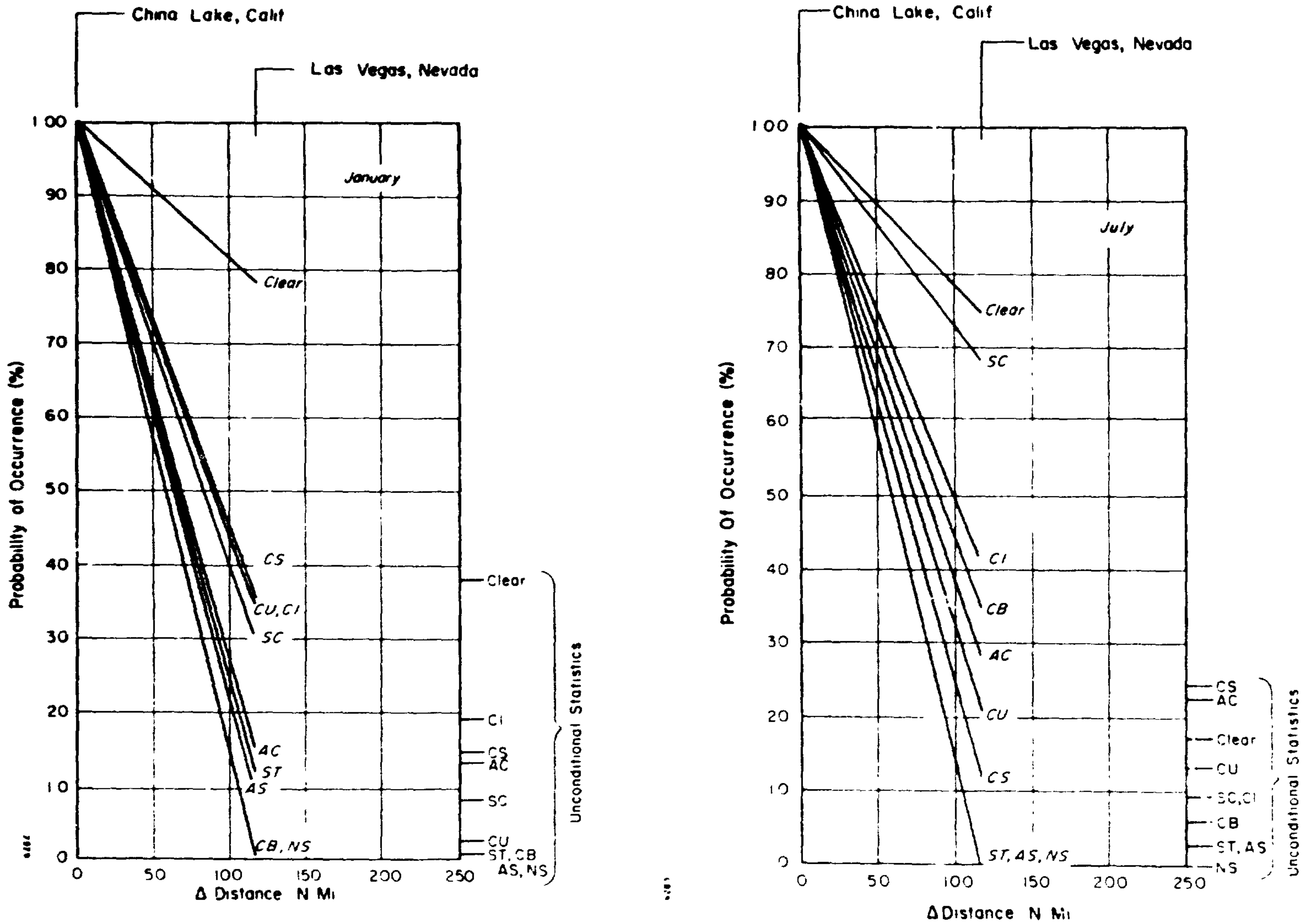


Figure 4-14 Spatial Conditionals for China Lake, California - Las Vegas, Nevada

frequency is highly dependent upon the hour of day; hence, statistics for the winter and summer seasons were compiled for every three hours across a 10-year period. The statistics assume a maximum of three layers; four layers are reported, but too rarely to necessitate a separate category. These cases are grouped with the three layer observations and no significant bias is expected.

4.3.1 Region 11

The winter season in Region 11 (Figure 4-15) shows a rather limited dependence on time; in fact, the number of cloud layers shows primarily a day-night dependence. Almost no variation is seen in the probability of one layer or three layers. The night (2100-0600 LST), and the day (0900-1800 LST) contrasts are thus apparent only in the probability of clear skies, and in the likelihood of two cloud layers. Sharp changes occur between 0600 and 0900, and again between 1800 and 2100, corresponding to dawn and dusk; the variability in probabilities between these time periods is so limited that it can almost be ignored. Analyses earlier in this report have indicated a lack of convective activity for this region and season; these statistics emphasize the absence of any cloudiness due to solar heating. In fact, much of the day-night differences might be based upon the reporter's ability to see the clouds, rather than upon changes in meteorological conditions.

One layer of cloudiness has the highest probability (approximately 50%) at all times for all stations except Belleville. At the other extreme, the probability of three cloud layers rarely reaches 0.05 and usually can be ignored. Clear skies show a 30-40% likeli[illegible] at night then drop to a 20-25% likelihood during the day. With an inv[illegible] correlation, the probability of two cloud layers runs 12% at night then increases to equal or exceed the probability of clear skies during the day.

The shift from mesoscale systems to convective cloudiness is evident in the cloud layer statistics found for summer. There, a very strong time dependence is visible. Clear skies have the highest probability of any cloud conditions at midnight, at three in the afternoon they have the lowest probability. In contrast, the probability of having two cloud layers is near 0.40 from 1200 to 1800 LST. Abrupt changes in the cloud layer probabilities occur between 0300 and 0600 LST and between 1800 and 2100 LST, again showing the change between daytime and nighttime reporting; however, considerable changes also occur between 0600 and 1800 LST.

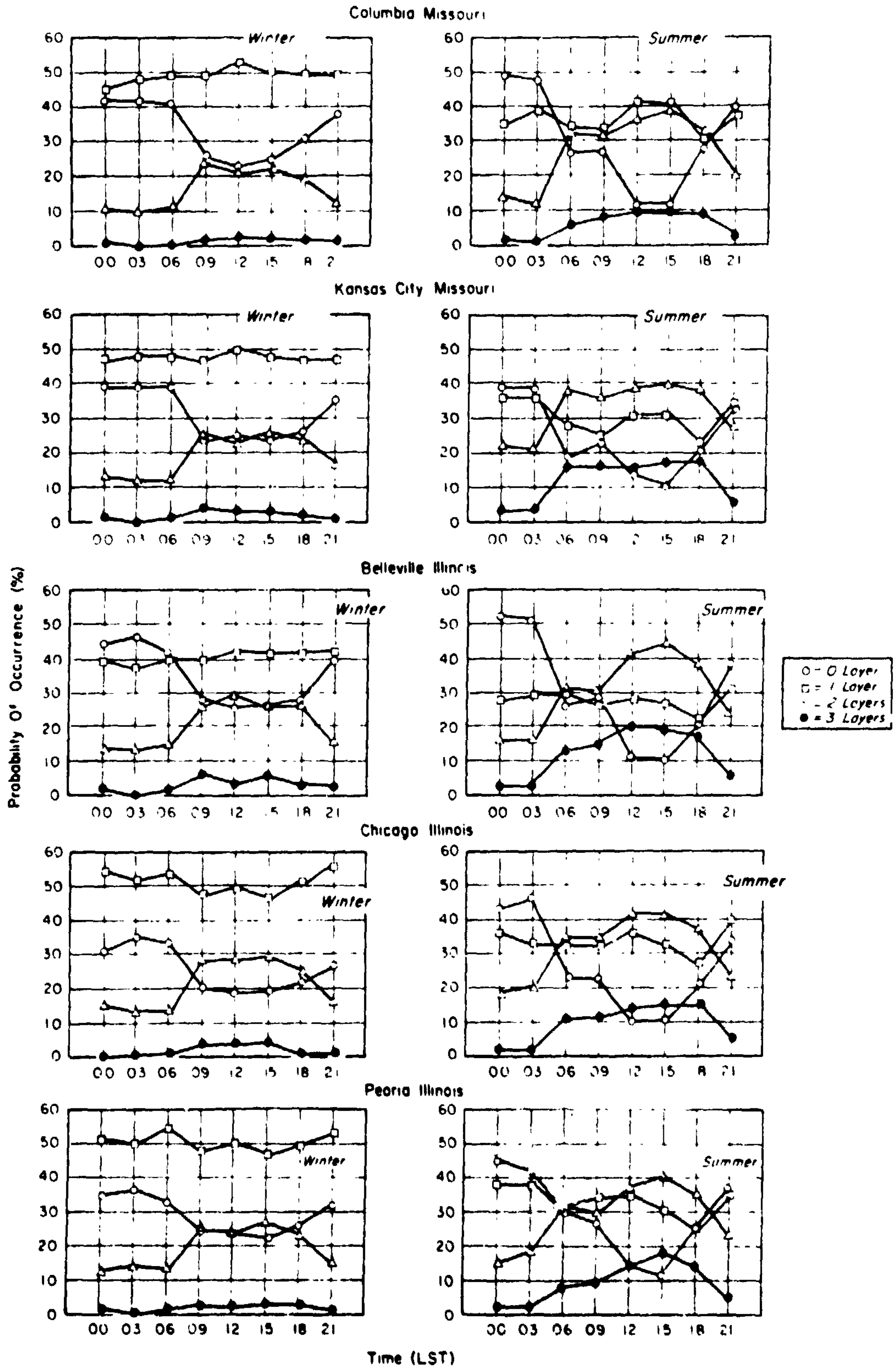


Figure 4-15 Diurnal Variability in the Number of Cloud Layers - Region 11

From 6:00 AM to 3:00 PM a general increase in cloudiness is visible. The probability of one cloud layer remains fairly constant but the likelihood of two and three cloud layers increases smoothly during this time period, reaching a combined probability of 55 to 65%. In a parallel effect, the probability of clear skies decreases to 10%. The trend then reverses until 9:00 in the evening when the cloud layer probabilities arrive at their nighttime plateau. These statistics thus clearly show the expected daytime buildup of cumuliform clouds, and the rapid disappearance of these clouds with sunset, while indicating a background of time independent synoptic scale cloudiness.

4.3.2 Region 30 (Old Region 2) and Region 18

The diurnal cycle in convective cloudiness is even more evident in Regions 30 and 18 (Figure 4-16) than in Region 11's summer because of the rarer occurrence of storm systems and frontal cloudiness. Both seasons show a midnight maximum and a 1500 LST minimum in clear skies; in summer this sky condition has by far the highest probability of occurrence. Clear skies seem to disappear abruptly with sunrise and reappear suddenly with sunset; however the change in cloudiness is spread quite equally over the probability of one, two, and three cloud layers. In the winter these changes are rather smooth and show more of a daytime-nighttime contrast than time dependence. This is similar to the statistics seen for Region 11's winter. More of a time dependence is seen in the summer with a definite maximum between 1200 and 1500; in fact, the probability of two cloud layers exceeds that for one cloud layer in Las Vegas for most of the daylight hours and shows a pronounced peak at 1500 LST. A high frequency of thunderstorms occurs here because of the neighboring mountains; this probably combines with the usual background of cirriform clouds to cause this result, or builds up into a multilayer cumuliform system. China Lake is not as influenced by orographic cloudiness.

4.4 Cloud Type Interdependence

Most of the analyses in this study have emphasized the predominant cloud type, and virtually ignored the existence of correlative cloud layers. With a few exceptions this permits an accurate estimation of the probabilities of these cloud types, and of their spatial and temporal dependence; however,

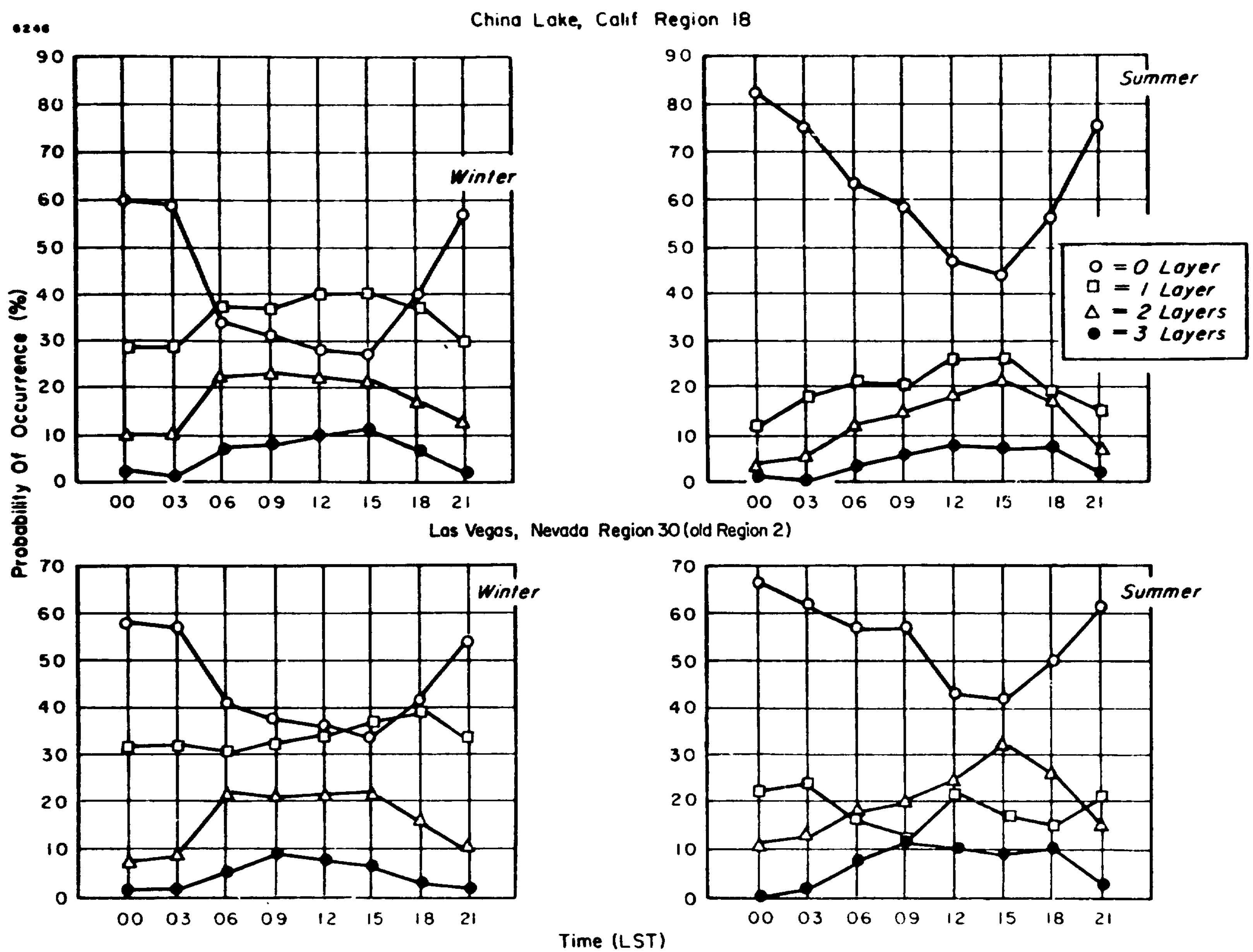


Figure 4-16 Diurnal Variability in the Number of Cloud Layers - Regions 30 and 18

as Section 4.3 showed, predominant cloud types are often not the only cloud types. For proper simulation of such situations, it is important to know which clouc types occur together and which cloud types are mutually exclusive.

To determine cloud type conditionality, seasonal statistics were computed for Kansas City and Columbia, Missouri; China Lake, California; and Las Vegas, Nevada. In each case, a count was made of all reported cloud types given a predominant cloud type. As the probability of three cloud layers rarely exceeded 10%, no attempt was made to keep separate counts of the second and third cloud layers. The resulting joint probabilities are thus independent of the number of layers reported. They are also independent of the time of day and are computed from the same ten-year period for which the other conditional probabilities were derived. Four predominant cloud types were selected for analysis: stratocumulus, stratus, altocumulus, and cirrus. Since these cloud types usually show a high probability of occurrence as a predominant cloud type (see Section 3), and are generally associated with a high percentage of cloud cover, they should provide a good indication of the distribution of secondary clouds. Figures 4-17 through 4-20 show these conditionalities.

The first item that becomes apparent from these figures is the high probability of certain cloud types being reported at more than one level. Considerable controversy has arisen in the various cloud statistics studies as to whether this occurred, some individuals claiming that a given cloud type is only reported once, and that at the lowest level it is seen. Others have claimed that if a cloud type occurs in two separate and distinct layers, it is reported at two different levels. These statistics clearly support the latter viewpoint, although for certain cloud types only. Stratus and stratocumulus show that, when a secondary layer is reported in winter, it has a 40% likelihood of being the same cloud type. On the other hand, cirrus is almost never reported at more than one level, and statistics compiled for cirrostratus indicate the same for that cloud type. This conforms to standard observing practices. It is possible to have one layer of stratus (possibly lifted fog) just above the surface at 100 feet, and through that layer another layer of stratus at 2000 feet can be seen. On the other hand, it would be very difficult to distinguish one layer of cirrus at 30,000 feet from another at 32,000 feet; if separate

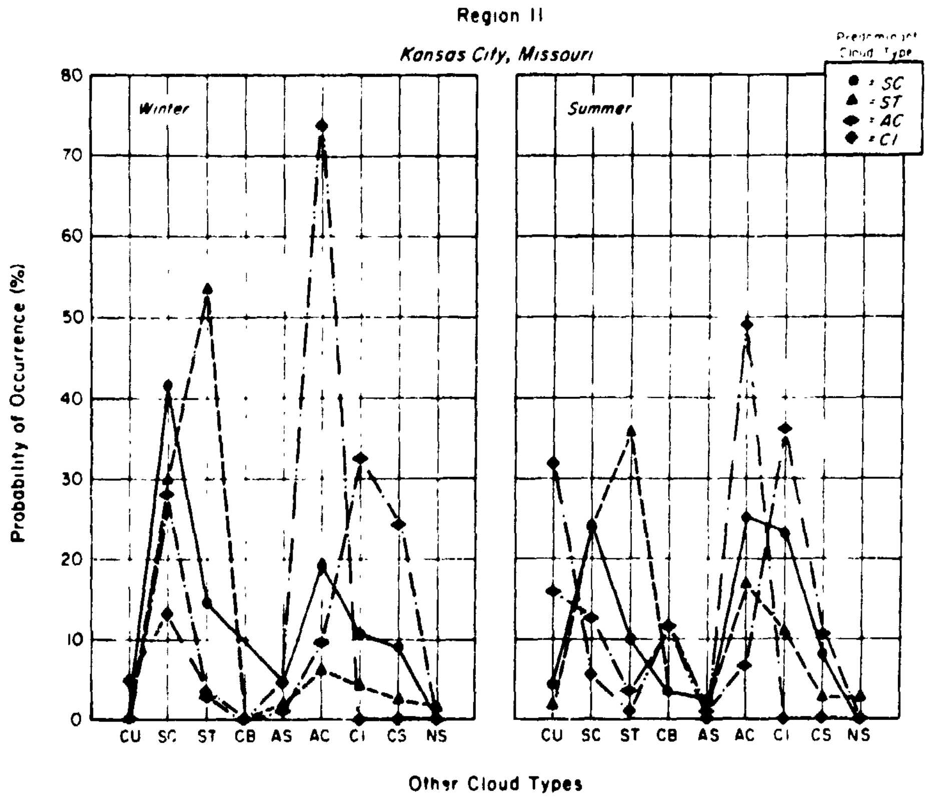


Figure 4-17 Cloud Type Interdependerce - Kansas City, Missouri

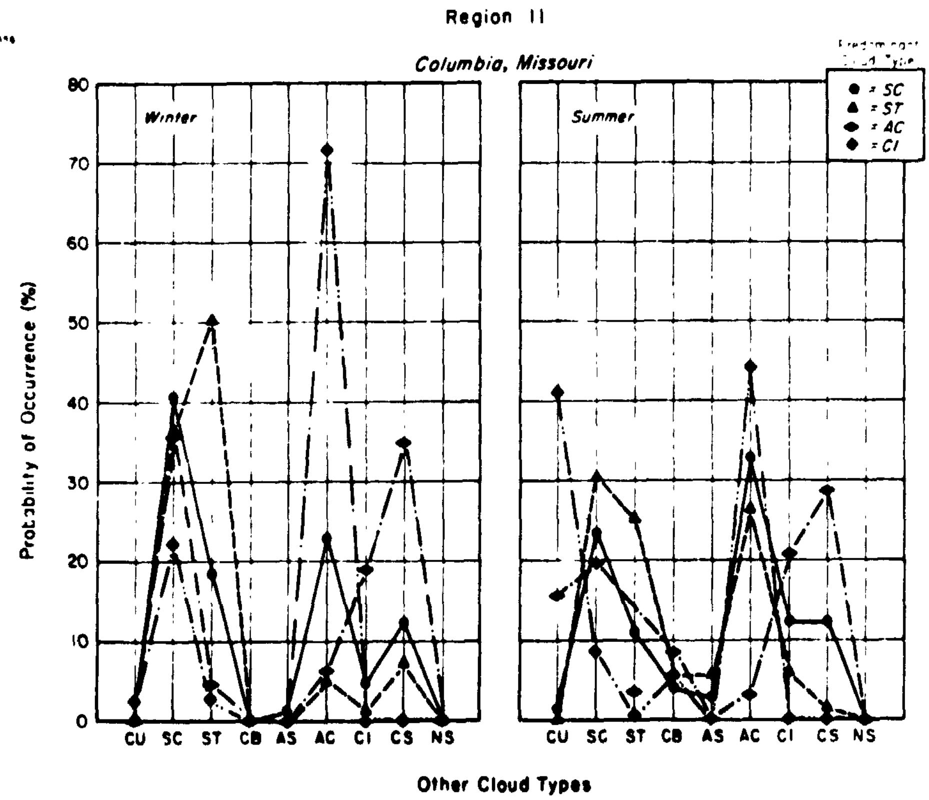


Figure 4-18 Cloud Type Interdependence - Columbia, Missouri

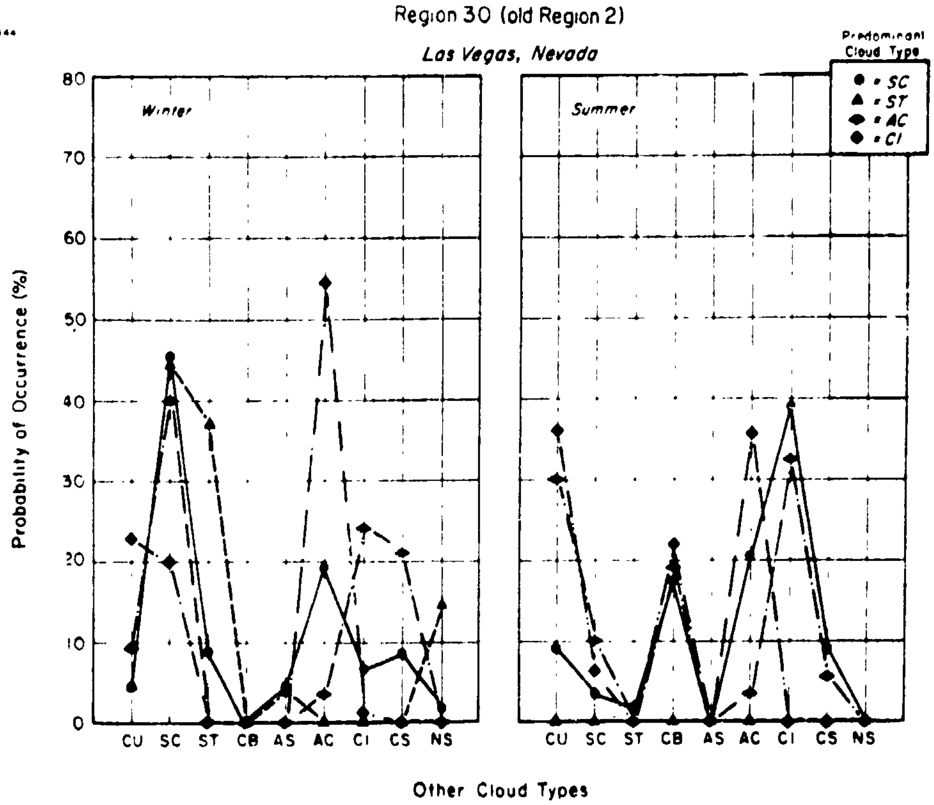


Figure 4-19 Cloud Type Interdependence - Las Vegas, Nevada

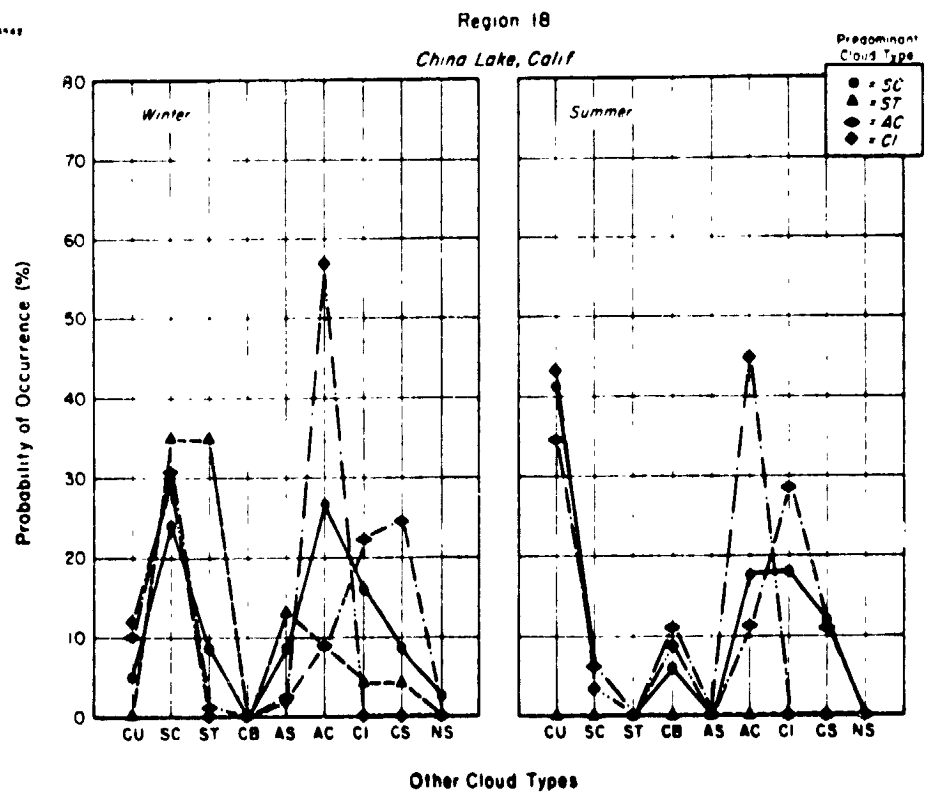


Figure 4-20 Cloud Type Interdependence - China Lake, California

layers existed, they would probably still be reported as one. Middle clouds show a mixture of these effects; more than one layer of altocumulus is sometimes reported, but not as often as multilayered stratocumulus is reported. Convective cloud types, e.g., cumulus and cumulonimbus, rarely are reported twice, perhaps because when these clouds are reported as the predominant cloud type, it is assumed that they are not continuous either horizontally or vertically.

A very clear correlation is seen between altocumulus and cirrus or cirro-stratus; this appears at all stations for both winter and summer. All of these clouds frequently occur together associated with frontal systems, altocumulus and cirostratus can be caused by vertical development due to highly unstable lapse rates, and cirriform clouds often form background sky conditions under which other clouds develop. Another high correlation is seen between stratocumulus and altocumulus, especially in Region 11 during the winter. Both cases tend to give a higher probability to the lower cloud type as the secondary cloud type because the high cloud is more often obscured when the lower layer is predominant.

In the summer, a predominant layer of cirrus is often accompanied by cumulus clouds; in the desert areas a correlation is also seen between altocumulus and cumulus and between stratocumulus and cirrus. Las Vegas also shows that cumulonimbus has at least a 15% probability of being the secondary cloud type whenever a second cloud type is reported (for all cloud types analyzed). This again reflects the very high frequency of thunderstorms in this area.

4.5 Summary

The analysis of this section showed that the occurrence of various cloud types depends not only on the general climate of an area, but also on other cloud types, previous cloud conditions, neighboring cloud conditions, and the time of day. Much more work is needed in this area to determine reliable statistics on conditionality that can be universally applied, and entire statistical areas (e.g., combined spatial-temporal statistics) remained to be investigated. However, the preliminary studies given here indicate the following conclusions:

- All cloud types show a very high probability of being present three hours after they were first sighted.

- Stratiform and cirriform clouds tend to persist a minimum of 12 hours; in Region 11 during the winter, stratus shows a temporal dependence after 36-hours.
- A diurnal cycle in convective cloudiness is clearly seen in 24-hour maxima for cumulus and cumulonimbus. In areas dominated by convective cloudiness, a related diurnal cycle is seen in the clear sky category.
- Cirrus clouds also show a diurnal cycle; this is probably caused by the difficulty in observing these clouds except under certain conditions.
- If any cloud types but cumulus or cirrus are reported, the likelihood of clear skies after 12 hours is still below the unconditional probability.
- Clear skies show the longest temporal persistence and the greatest spatial extent.
- The report of any cloud type at a location greatly increases its probability of occurrence in any direction within a 100 n. mi. radius.
- Stratiform clouds, in the winter at least, tend to extend out to at least 225 n.mi.; most other clouds show less of a spatial extent in the west-east direction.
- Clouds associated with a front show a greater spatial dependence in the south-north direction than in the west-east, reflecting the orientation of most frontal systems.
- Differences in terrain can rapidly destroy spatial dependence.
- Winter reports of cloud layers show only daytime-nighttime differences; summer reports are much more time-dependent.
- The probability of one cloud layer is almost time independent; the probability of clear skies and of two cloud layers is highly time dependent: the former peaking at midnight, the latter at 3:00 pm.
- The lower level stratiform clouds are often reported at more than one level, cirriform clouds are never reported as more than one layer.

- Because of obscuration, the higher level clouds are usually less likely to be reported as secondary cloud types than are the lower clouds.
- Stratocumulus, altocumulus, and cirriform clouds tend to occur jointly.
- In the desert areas in the summer, the prodominant layer of cirrus is often reported with a secondary layer of cumulus or cumulonimbus.

5. MISSION SIMULATION STUDIES

5.1 Objective

The primary objective of the current phase in mission simulation studies was to develop and test an algorithm which would simulate not only the cloud cover conditions, but also the structure of the atmosphere, along an orbital track. The statistical data base for the algorithm is provided by the cloud cover, type, and layer statistics, and the 4-D model atmosphere statistics developed in the studies cited in the Introduction. The successful implementation of such a comprehensive simulation scheme would permit earth-viewing mission simulation studies of not only visible sensors but also infrared and microwave sensors.

The obvious impetus for the comprehensive mission simulation studies is the rapid advance being made in the development of multi-sensor earth viewing spacecraft missions which go beyond the photographic observations of the earth's surface features. Many of the current spacecraft carry infrared and microwave sensors, and the EOS series of satellites, planned for the late 1970's as a follow-on to the ERTS, will apparently carry a multi-sensor package. For these spacecraft, mission analysis requires more than a simulation of the binary decision of cloud or no cloud; instead the simulation of the totality of atmospheric effects is required. These effects are deducible from atmospheric parameters of clouds, temperature, and moisture structure through appropriate interaction models (see, for example, Gaut and Reifenstein, 1972) once the wavelengths of the observation set are specified. The important parameters to be simulated in mission studies are therefore the atmospheric parameters statistics of which are already contained in the set of cloud statistics and in the 4-D atmospheric models.

5.2 Approach

In the Interim Report (Chang, Willand and Fowler, 1973) prepared under the current study, an approach towards a comprehensive mission simulation scheme was proposed. This scheme is briefly summarized in the set of flow charts shown in Figure 5-1. The simulation initializes and selects a cloud cover

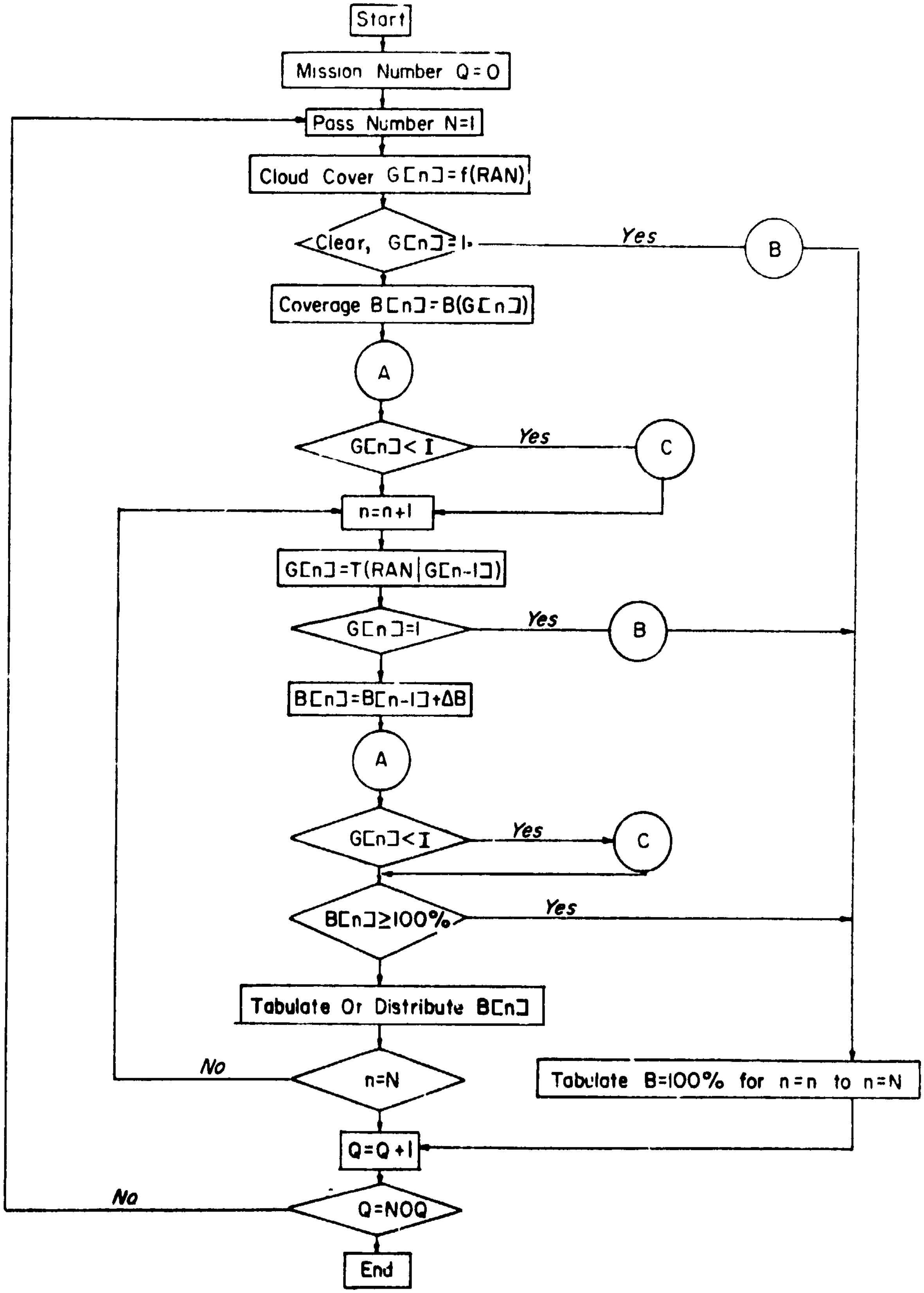


Figure 5-1 Proposed Comprehensive Mission Simulation Scheme

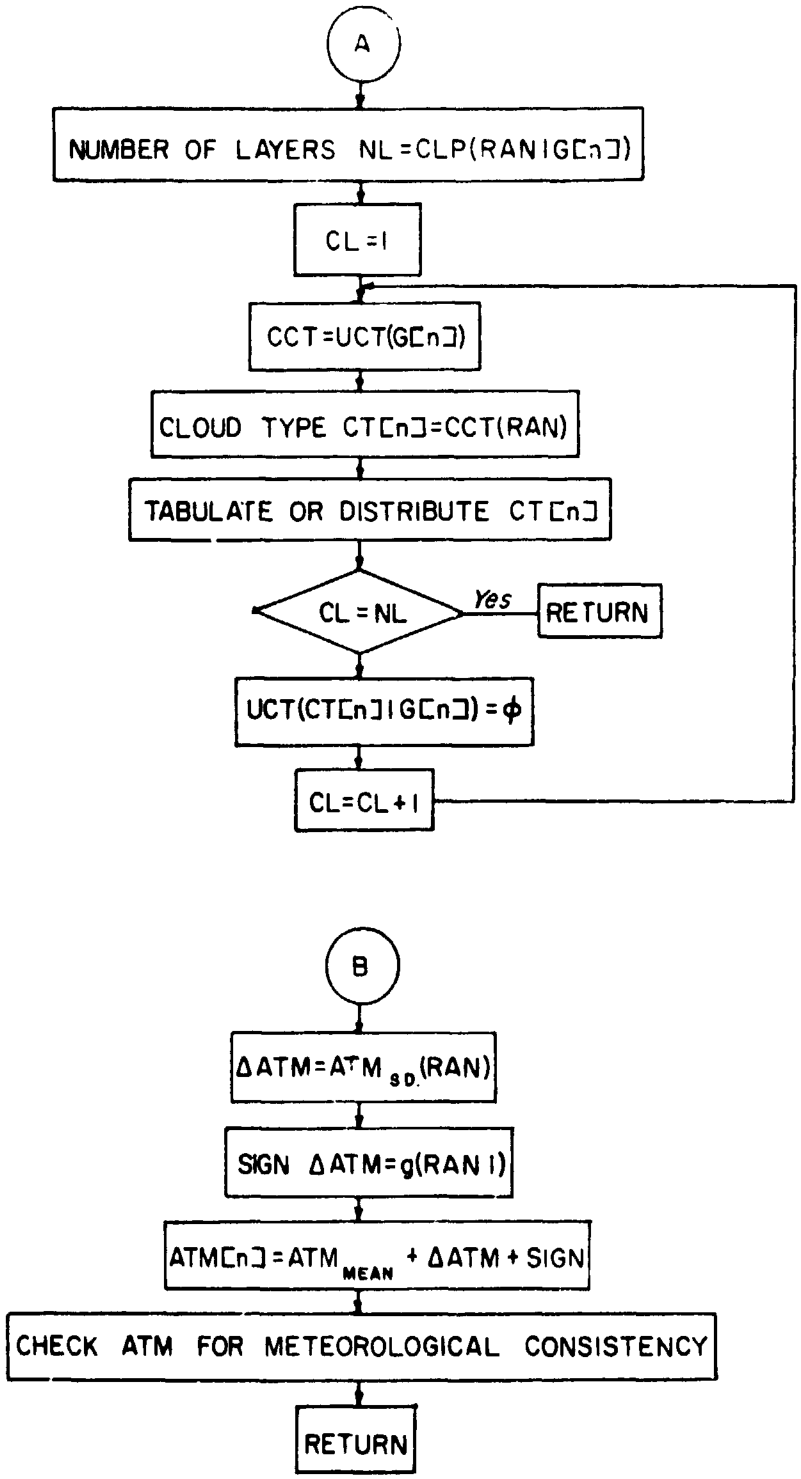


Figure 5-1 Continued

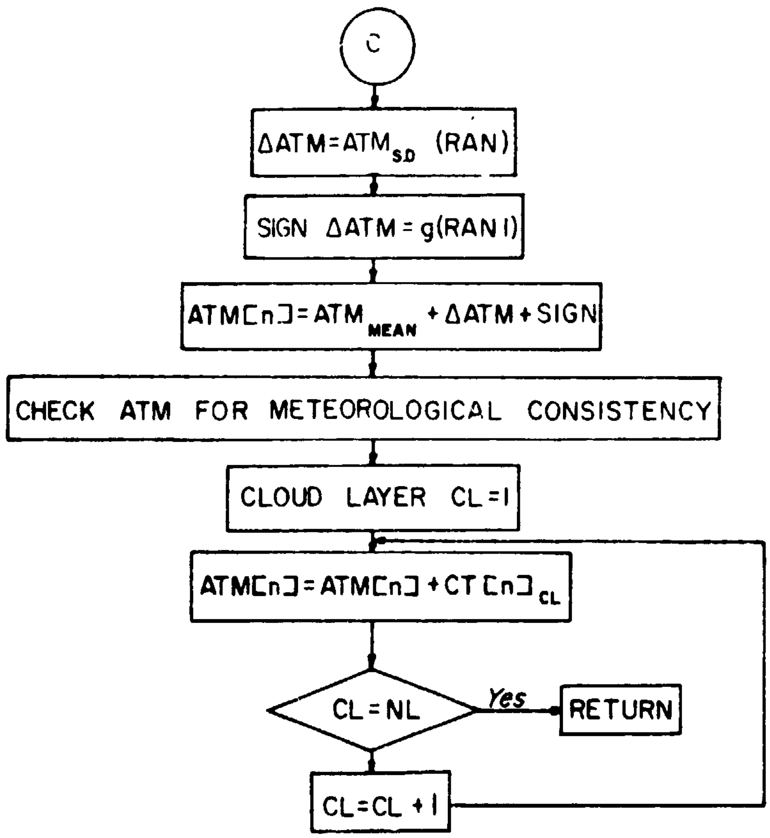


Figure 5-1 Continued

amount using the same Monte Carlo procedure used in previous simulation approaches (see for example, Sherr et al, 1968). Then, if the skies are found to be clear, the atmospheric statistics appropriate to that locale are obtained. A random number is selected ($0 \leq R \leq 1$) and is multiplied by the standard deviation for each term. A second random number is chosen; if it is greater than 0.5, the values are added to the means of each parameter at each level. The resulting atmospheric profile is then examined for atmospheric consistency; that is, it is checked for hydrostatic consistency, excessive supersaturation, negative values of moisture, etc. If necessary, the process is repeated and a new profile selected. When the atmosphere has been approved, it is stored for future use.

If the cloud cover amount is greater than 0, the simulation proceeds to select the number of cloud layers and the cloud type for each layer. At this point in the algorithm there is an option by which an atmosphere can be selected if the cloud cover is less than an input (given) value. If the presence of clouds has an effect so great that no evaluation of atmospheric effects would be worthwhile, the program continues. Otherwise, the simulation selects an atmosphere by the method mentioned above. This atmosphere is then altered by the insertion of cloud parameters (liquid water content, modal radius, etc.) at the selected altitudes and by setting the water vapor at those levels to saturation. The modified atmosphere is then retained, and permits a generalized computation of the interference found in the visible, infrared, or microwave.

It was pointed out in this previous study that before a scheme, such as the one proposed above, can be tested, a number of preliminary studies have to be performed. These include:

1) Tests of the Monte Carlo, Markov scaling, and other mathematical operations required for simulation on the cloud type and cloud layer statistics.

2) Development of a simulation algorithm for the generation of realistic atmospheric temperature and moisture profiles using the 4-D model atmospheres.

The results of these studies are presented and then used in the mission simulation experiment.

5.3 Mathematical Tools Used in Mission Simulation

Three basic mathematical routines have been developed to apply the global cloud statistics to mission simulation. The first, and most important, is the Monte Carlo procedure developed by Sherr et al (1968) to permit the random selection of cloud cover amounts based upon their unconditional probabilities of occurrence. The second is the Markov scaling procedure (Greaves et al, 1971) which uses the spatial and temporal conditionals of cloud cover to predict the occurrence of a cloud cover amount at a given distance or time away from a known occurrence of cloud cover. The third is a small subroutine which permits the selection of tenths of cloud cover given a cloud cover category. These procedures, and their applicability to cloud type statistics, will be briefly discussed.

5.3.1 Testing of the Monte Carlo Procedure

The application of the Monte Carlo procedure to cloud cover statistics has been extensively tested and verified (Sherr et al, 1968; Greaves et al, 1971). Its applicability to cloud type and number of cloud layer statistics derived from limited samples has never been tested. An experiment was therefore conducted to test its validity.

A suborbital track was chosen across four cloud cover regions (see Sherr et al, 1968) with points selected as in Figure 5-2. The cloud cover amount, the number of cloud layers, and the associated cloud types, were then assigned to each point along the track using the Monte Carlo procedure to simulate the conditions encountered during a mission. This process was repeated 25 times to obtain a representative estimate of the cloud probabilities. All occurrences for each cloud amount, type and number of layers were then summed for a region and divided by the total number of occurrences for all conditions for that region. Figure 5-3 shows the resulting deviations of these simulated unconditional statistics from the satellite unconditional probabilities given for that time period.

The agreement between the simulated unconditionals and the actual unconditionals is quite good with no differences in probability exceeding 0.1. The best agreement is found for Region 8 which had the largest data sample (350 events) indicating that a data set of this size is statistically valid. Likewise, it would appear that the 50 events used for Region 13 are not quite

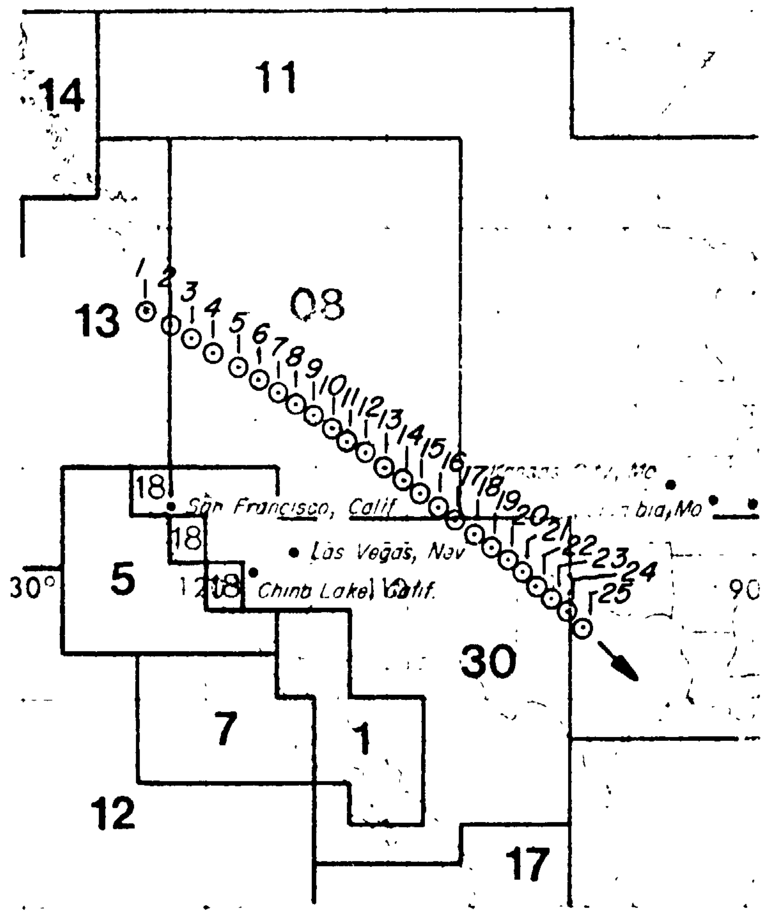


Figure 5-2 Mission Simulation Point Locations

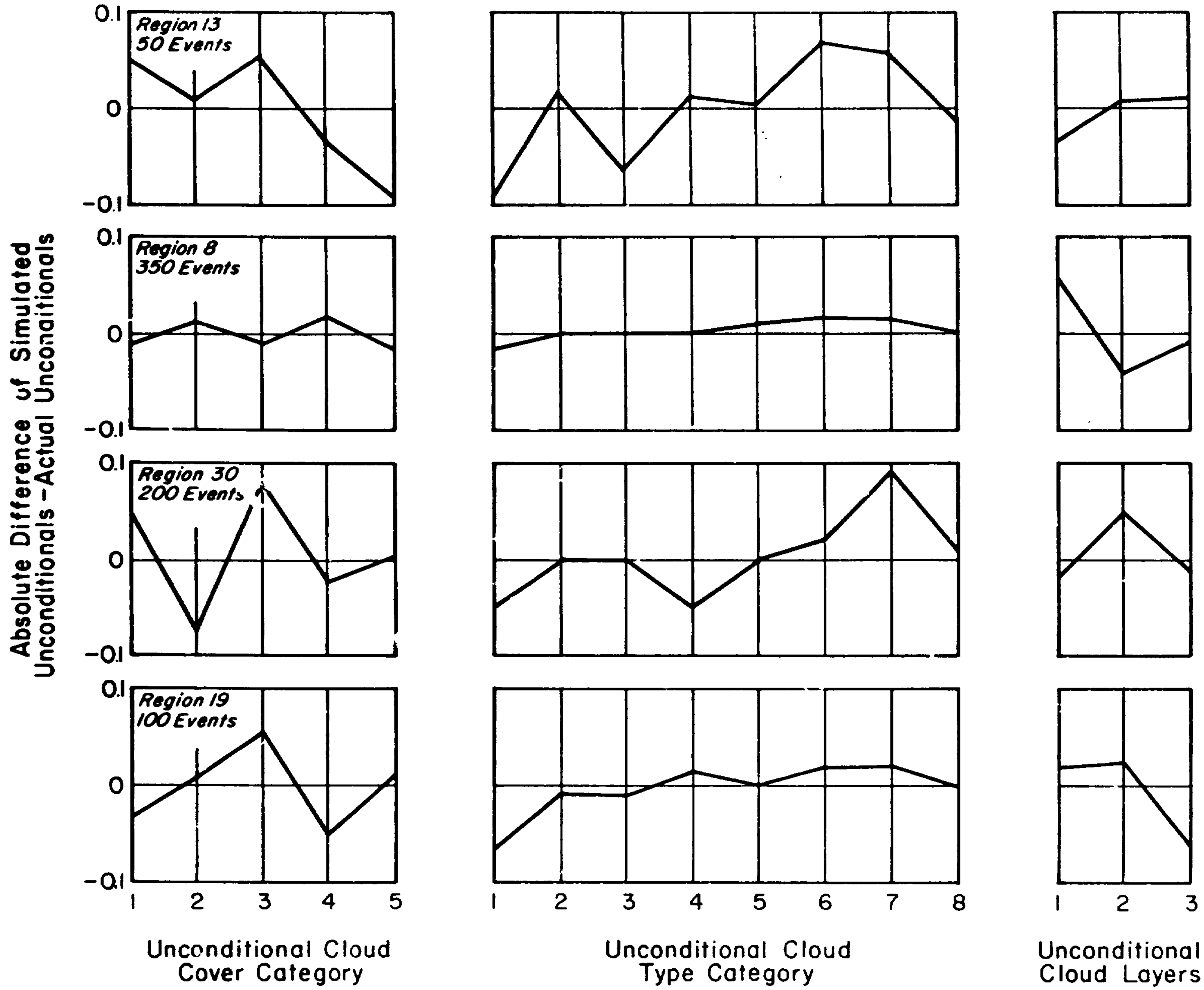


Figure 5-3 Results of the Monte Carlo Procedure

sufficient to duplicate exactly the initial statistics. In all cases, however, the use of the Monte Carlo procedure appears to be completely justified and quite reliable in its results over a large data set.

5.3.2 The Markov Scaling Procedure

The Markov scaling procedure used to specify a cloud cover amount at a given distance or time from a known event assumes that cloud cover amounts have the properties of a Markov chain. That is, the occurrence of any event is uniquely determined by the event just preceding it. This may not be a completely valid assumption for all cloud cover conditions, but it does in many ways reflect the spatial and temporal dependencies in the atmosphere. It also provides a statistical tool which seems to reproduce well the non-linear decay of conditionality in cloud cover and thus is empirically, as well as theoretically, justified for use.

In its present formulation, application of the procedure often results in a message stating that Markov scaling is unreliable. When this occurs, a linear approximation to the decay is used. A study of the Markov scaling computer subroutines showed that the message "MARKOV SCALING UNRELIABLE" can be misleading and inappropriate. The message is printed whenever the conditions for a Markov chain were not met in the conditional statistics; that is, whenever the assumption of unique dependence of one event upon the previous event was not justified by the data. This occurs when all elements in a row shows that the conditional probabilities for all cloud categories were virtually identical to the unconditional probabilities for those categories, and thus not dependent upon a preexisting condition.

Table 5-1 gives an example of this situation for the spatial conditionals appropriate to Region 13, month 8 (see Table 5-2). Row 3 gives the spatial conditional probabilities for each cloud cover category given the occurrence of cloud category 3. Comparison of those values with the unconditional probabilities for each category as shown in Table 5-2 shows that the sum of the deviations from the unconditionals equals zero. It is clear from these statistics that no spatial dependency for cloud cover category 3 exists. The assumption of a Markov chain is thus invalid, and the Markov scaling routine is replaced. In this case a two-term approximation to the rate of decay was also tried and discarded; linear interpolation appears to be the only approach to scaling these statistics.

TABLE 5-1

SELECTED CLOUD COVER STATISTICS FOR
REGION 13, MONTH 8

Unconditional
Cloud Cover Category

1.	0.190
2.	0.210
3.	0.120
4.	0.330
5.	0.150

Spatial Conditionals
Cloud Cover Category

0.350	0.210	0.140	0.240	0.060
0.080	0.340	0.210	0.240	0.130
0.210	0.190	0.100	0.340	0.160
0.180	0.130	0.040	0.460	0.190
0.140	0.210	0.150	0.350	0.150

TABLE 5-2

COMPARISON BETWEEN CONDITIONAL P(i| j) AND
UNCONDITIONAL P(i) CLOUD COVER
STATISTICS FOR REGION 13, MONTH 8

P(1| 3)	-	P(1)	=	.210	-	.190	=	.02
P(2| 3)	-	P(2)	=	.190	-	.210	=	-.02
P(3| 3)	-	P(3)	=	.100	-	.120	=	-.02
P(4| 3)	-	P(4)	=	.340	-	.330	=	.01
P(5| 3)	-	P(5)	=	.160	-	.150	=	.01
Sum of the deviations								0.00

Examination of the results of scaling for other regions indicates that Markov scaling does work most of the time. In fact it works quite well. Figures 5-4 through 5-6 show examples for Regions 8, 30, and 19. Comparison of the values given for points 3 through 13 shows that in most cases the conditionality decreases sharply for the first 350 n.mi. then more slowly with increasing distance. At 600 n.mi. the spatial dependence seems to have disappeared for cloud category 3 in Region 8 (Figure 5-4), although some conditionality is still seen for the clear sky situation. Because the conditionality at 800 n.mi. is so low, the unconditional statistics are used for the next point and the scaling procedure is reinitialized. Since cloud cover does show a great change in the first 300 n.mi. (Greaves et al, 1971) and very little spatial dependence after 800 n.mi., these statistics appear to reproduce well the observed physical phenomena.

5.3.3 Selection of Tenths of Cloud Cover from Cloud Amount Categories

The above procedures adjust probabilities of cloud amount categories and permit the random selection of given cloud amounts. Since most categories represent ranges of cloud cover amounts (Table 5-3), and most studies use tenths of cloud amounts, another procedure was developed in this study to get cloud cover in tenths from the given cloud categories.

This procedure, incorporated into the subroutine CTENTH, assumes that the tenths of cover within each category occur with equal probability. Consequently, a cumulative probability array (Table 5-4) can be derived for each category which permits the use of a Monte Carlo procedure in the selection of tenths of cloud cover given a cloud cover category.

Since this subroutine adds an additional capability in the use of the cloud statistics, it is listed in Appendix C and its inclusion in the library of simulation subroutines is recommended.

5.4 Simulation of Atmospheric Soundings

An investigation was undertaken to determine the feasibility of using each of several simulation techniques to realistically simulate profiles

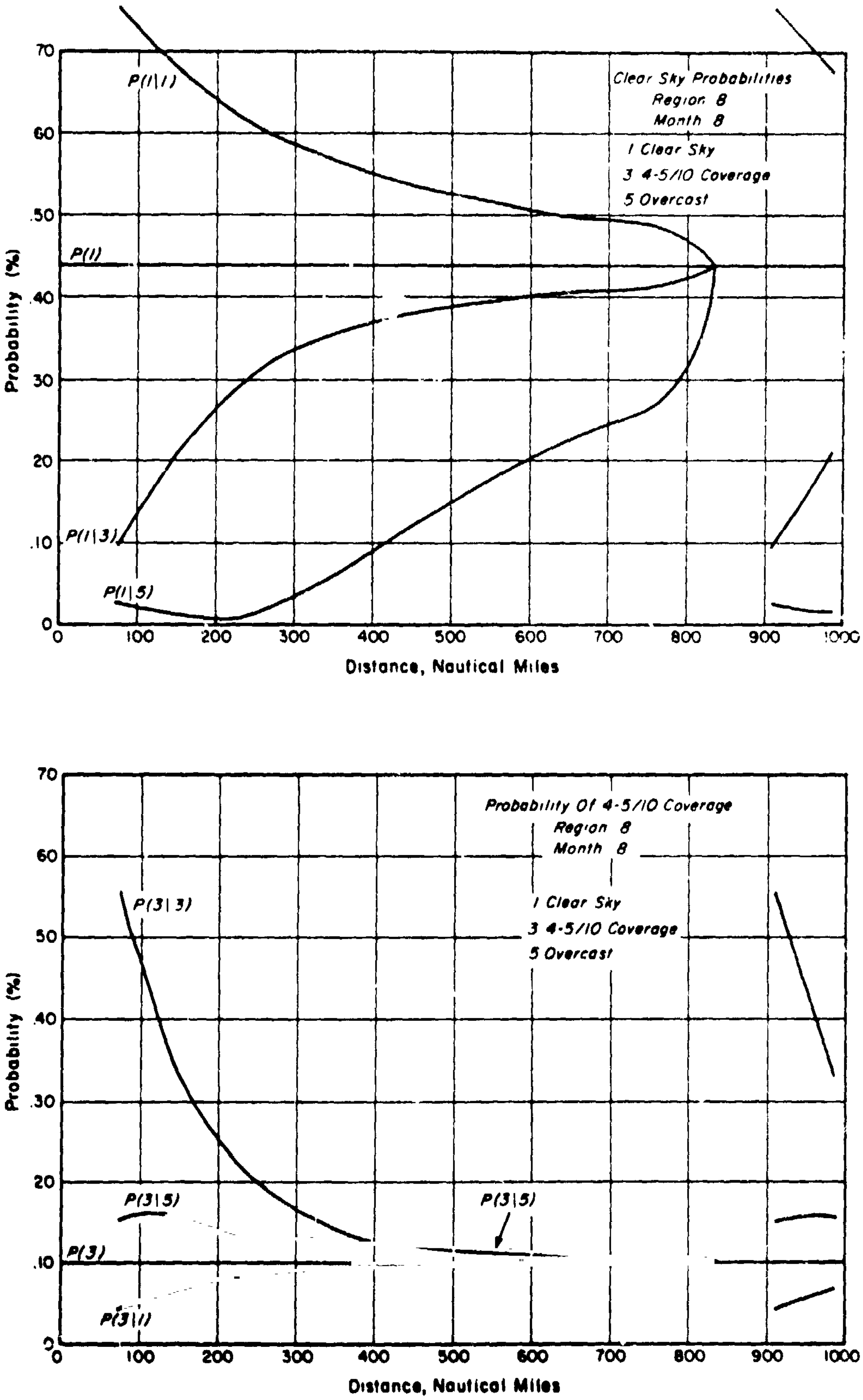


Figure 5-4 Cloud Cover Probabilities Derived from the Markov Scaling Procedure - Region 8

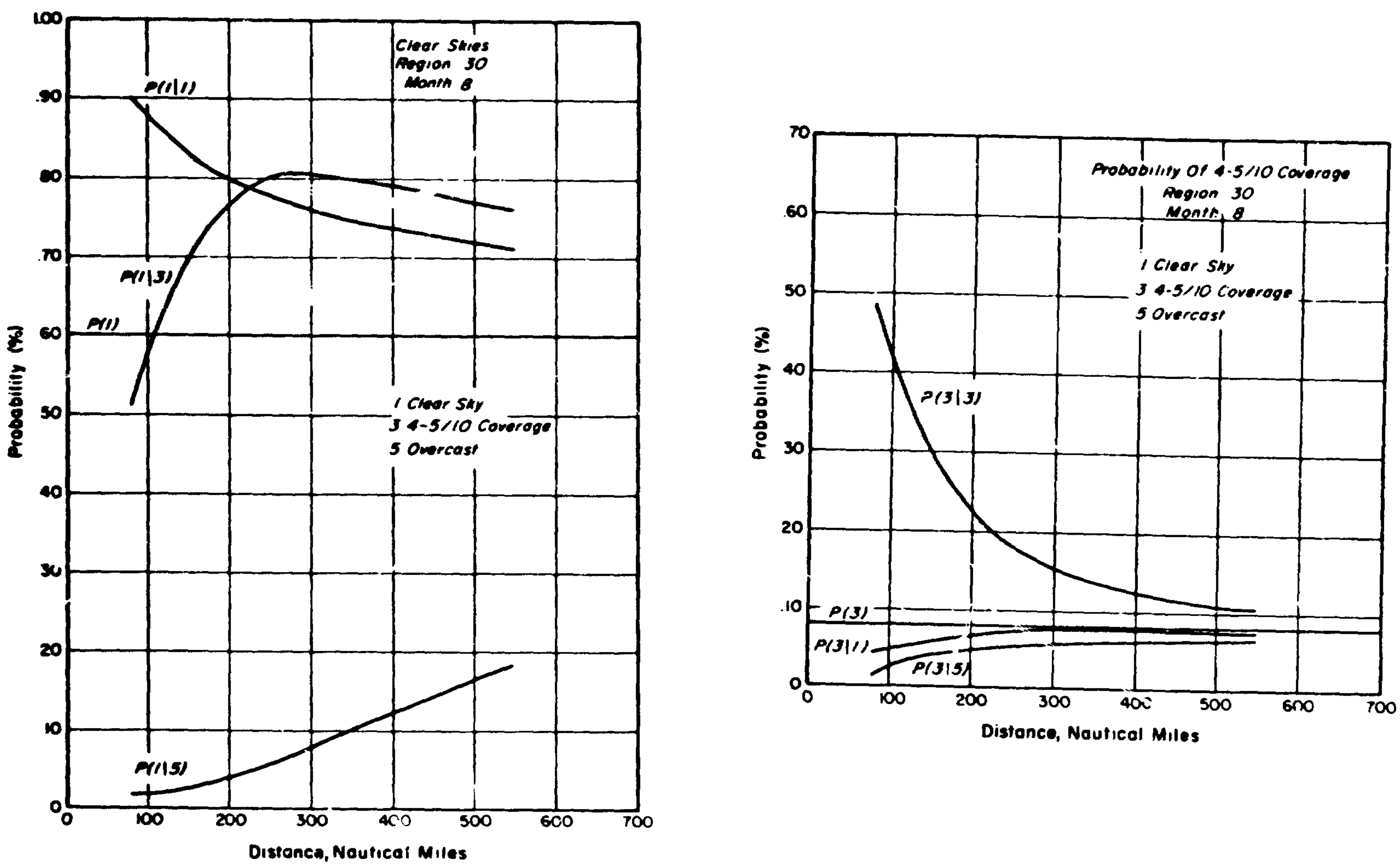


Figure 5-5 Cloud Cover Probabilities Derived from the Markov Scaling Procedure - Region 30

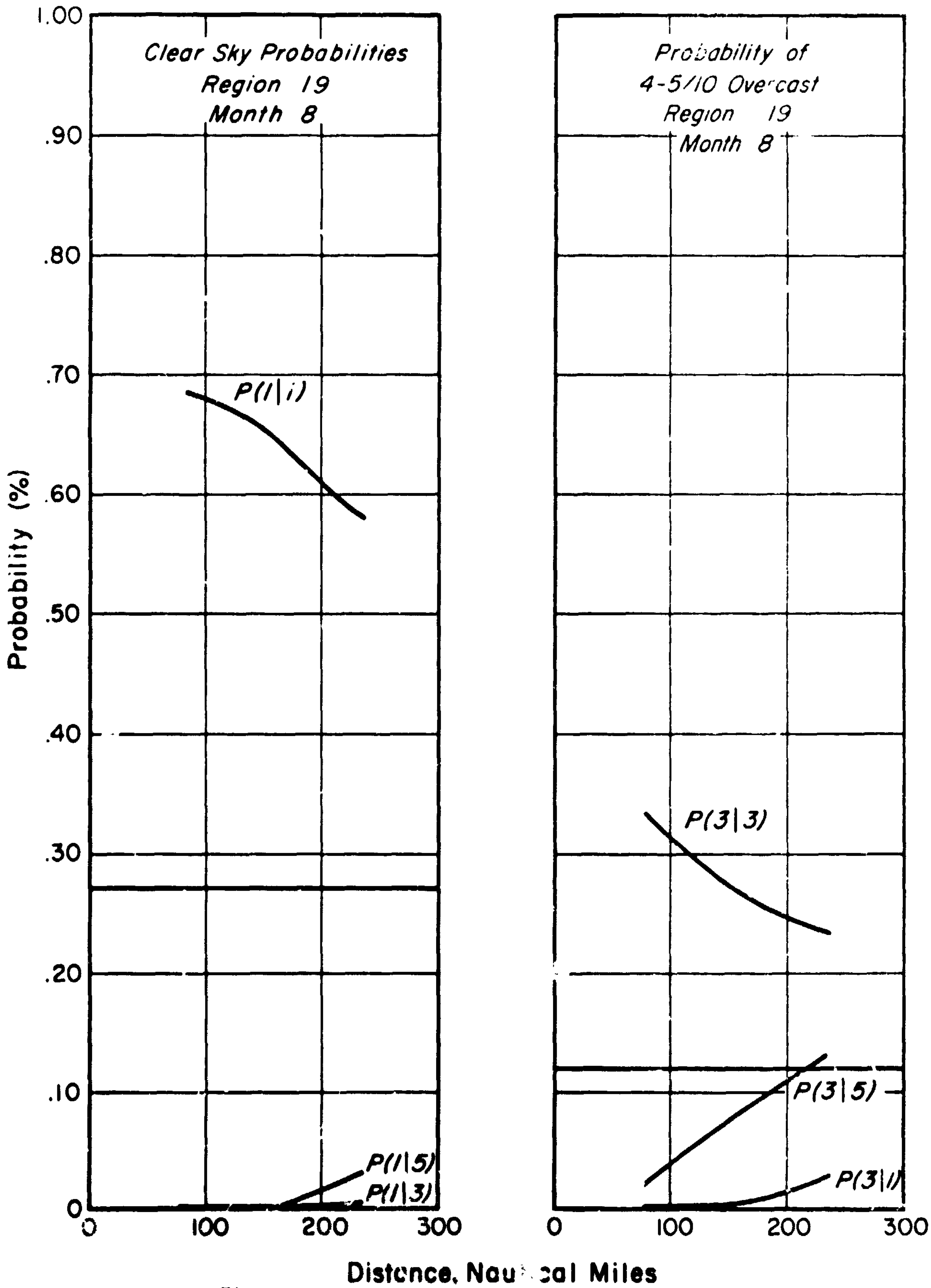


Figure 5-6 Cloud Cover Probabilities Derived from the Markov Scaling Procedure - Region 19

TABLE 5-3

CLOUD COVER AMOUNTS

Category	Tenths
1	0
2	1,2,3
3	4,5
4	6,7,8,9
5	10

TABLE 5-4

PROBABILITY OF CLOUD COVER IN TENTHS
GIVEN CLOUD COVER CATEGORY

Cloud Category	1	2			3		4				5
Cloud Cover Tenths	0	1	2	3	4	5	6	7	8	9	10
Cumulative Probability	1.0	0.33	0.66	1.0	0.5	1.0	0.25	0.50	0.75	1.0	1.0

of temperature and humidity while utilizing data on hand to the fullest extent possible. Data were taken from three representative stations, each within a distinct region of the 4-D model, for the winter (December through March) season. These stations were Thule (Region 1), Washington, D.C. (11), and Trinidad (22), representing arctic, middle latitude, and tropical atmospheres. A brief summary of each technique and its ability to satisfy the requirements of realistic profiles and greatest use of data on hand is presented below.

5.4.1 Independent Selection of Variables

For the first attempt at simulating atmospheric profiles, a temperature (or specific humidity) was computed at each level by a random selection technique involving the corresponding mean and standard deviation. Since each temperature or humidity was computed independently, there was no correlation between values at adjacent levels and "zigzag" profiles were produced which did not realistically portray the atmosphere. Consequently this method was eliminated from further consideration.

5.4.2 Derivation Utilizing Lapse Rate

One measure of the mutual dependence of temperature, and humidity to a lesser extent, at two adjoining levels is the lapse rate, γ, of the intervening layer. The mean, $\bar{\gamma}$, and standard deviation, σ_γ, for all such layers can be used to obtain the mean and standard deviation of the profiles of temperature and humidity. A discussion of the construction of temperature profiles will follow a brief description of the method of computing $\bar{\gamma}$ and σ_γ.

Means and standard deviations of lapse rate (γ and σ_γ) were computed for layers one kilometer thick from the surface to 15 kilometers (except 14 km for Thule) for three stations (see above) which represent arctic (Thule), middle latitude (Washington, D.C.), and tropical (Trinidad) atmospheres. For this investigation, samples of over 100 soundings from each station were selected for the winter season.

The data was stored on NMC tapes giving temperature, relative humidity, and height for pressure levels from 1000 mb (except when surface pressure < 1000 mb) in 50 mb increments to 100 mb. Data from levels above 100 mb were not used in this preliminary study. The surface pressure, temperature, and humidity were also listed on the tapes. These data were converted to a format with temperature and specific humidity at kilometer levels. Using these data, lapse rates were computed for each sounding; the lapse rates were then processed for all soundings to give $\bar{\gamma}$ and σ_γ for both temperature and humidity. Figures 5-7 through 5-9 show the results for the three stations.

The lapse rate for each layer is computed by a random selection technique that utilizes the corresponding mean and standard deviation. For this investigation, it is assumed that $\bar{\gamma}-\sigma_\gamma \leq \gamma \leq \bar{\gamma} + \sigma_\gamma$.

As a first step in the construction of atmospheric profiles, the lapse rate for each layer is computed by a random selection technique that utilizes the corresponding mean and standard deviation. For this investigation it is assumed that $\bar{\gamma}-\sigma_\gamma \leq \gamma \leq \bar{\gamma} + \sigma_\gamma$. Secondly, the temperature of a representative layer (surface, 1km, etc.) is chosen by a random selection technique based on the mean and standard deviation. The temperature of the level above (or below) is determined by adding (subtracting) the lapse rate of the intervening layer to (from) the initial temperature ($T \underset{(-)}{+} \gamma = T$). This process continues until all the remaining levels are assigned a temperature.

Clouds can be readily inserted into the simulated sounding when this method of obtaining atmospheric profiles is used. The temperature is assumed to fall at the moist adiabatic lapse rate for that portion of the sounding which is assumed to pass through cloud. When a layer is only partly in cloud, the lapse rate is an average of the moist adiabatic and that value of γ selected for the layer by the random selection process. In the case of an inversion, the mean lapse rate for the layer is assigned a new value of, say, $\bar{\gamma} = 0$ or $-1.0°C\ km^{-1}$.

The profiles of specific humidity are constructed in a manner similar to the one for temperature. However, the standard deviation of lapse rate may exceed the mean value, possibly resulting in the computation of negative values of humidity for some levels. To avoid that problem, and that of supersaturation, the humidity, ρ, is constrained so that $0 \leq \rho \leq \rho_s$ (saturated value of ρ). A value of $\rho = 0$ represents an amount of moisture less than the minimum value detectable by humidity sensors.

The temperature profile is constructed before the one for humidity so that ρ_s can be calculated. Initially, the humidity profile is computed as if no clouds existed. For those levels which have been determined to lie within a cloud, ρ is set equal to ρ_s. If a level becomes 'saturated' when no clouds have been assigned to that part of the simulated sounding, ρ can be arbitrarily given a value less than ρ_s, say, $\rho = 0.95\rho_s$.

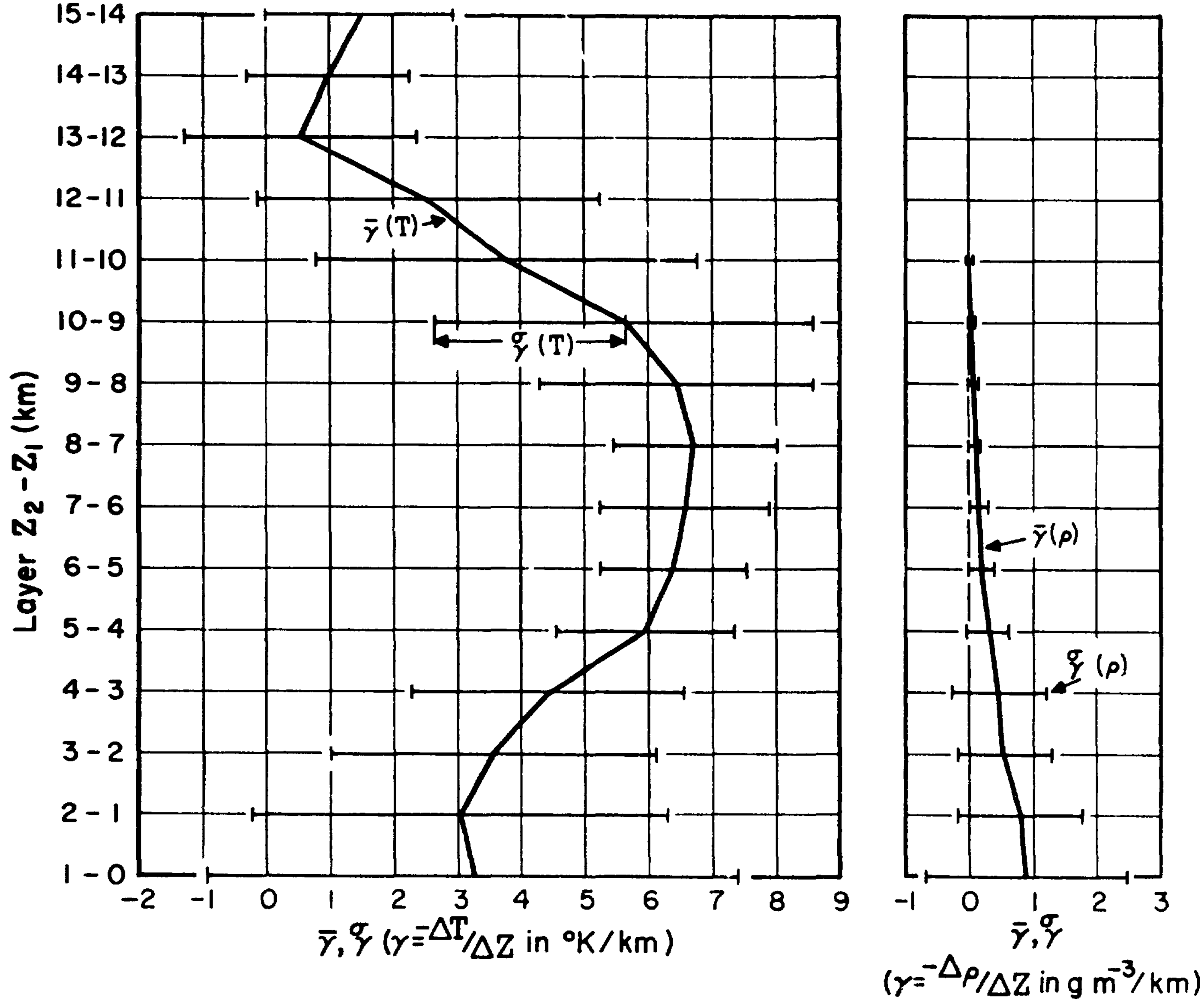


Figure 5-7 The Mean and Standard Deviation of the Lapse Rates of Temperature and Humidity - Washington, D.C.

7847

7548

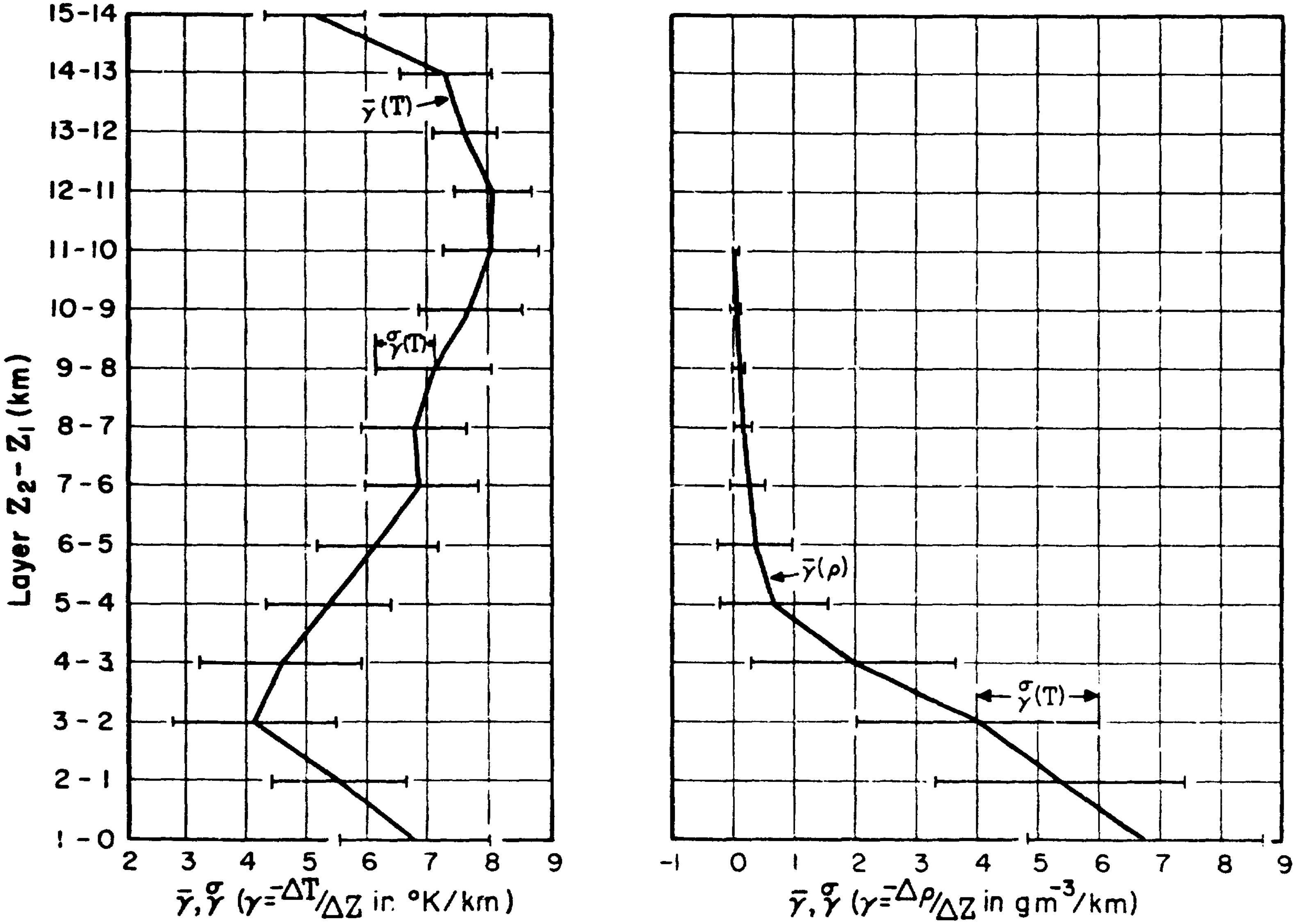


Figure 5-8 The Mean and Standard Deviation of the Lapse Rates of Temperature and Humidity - Trinidad

7544

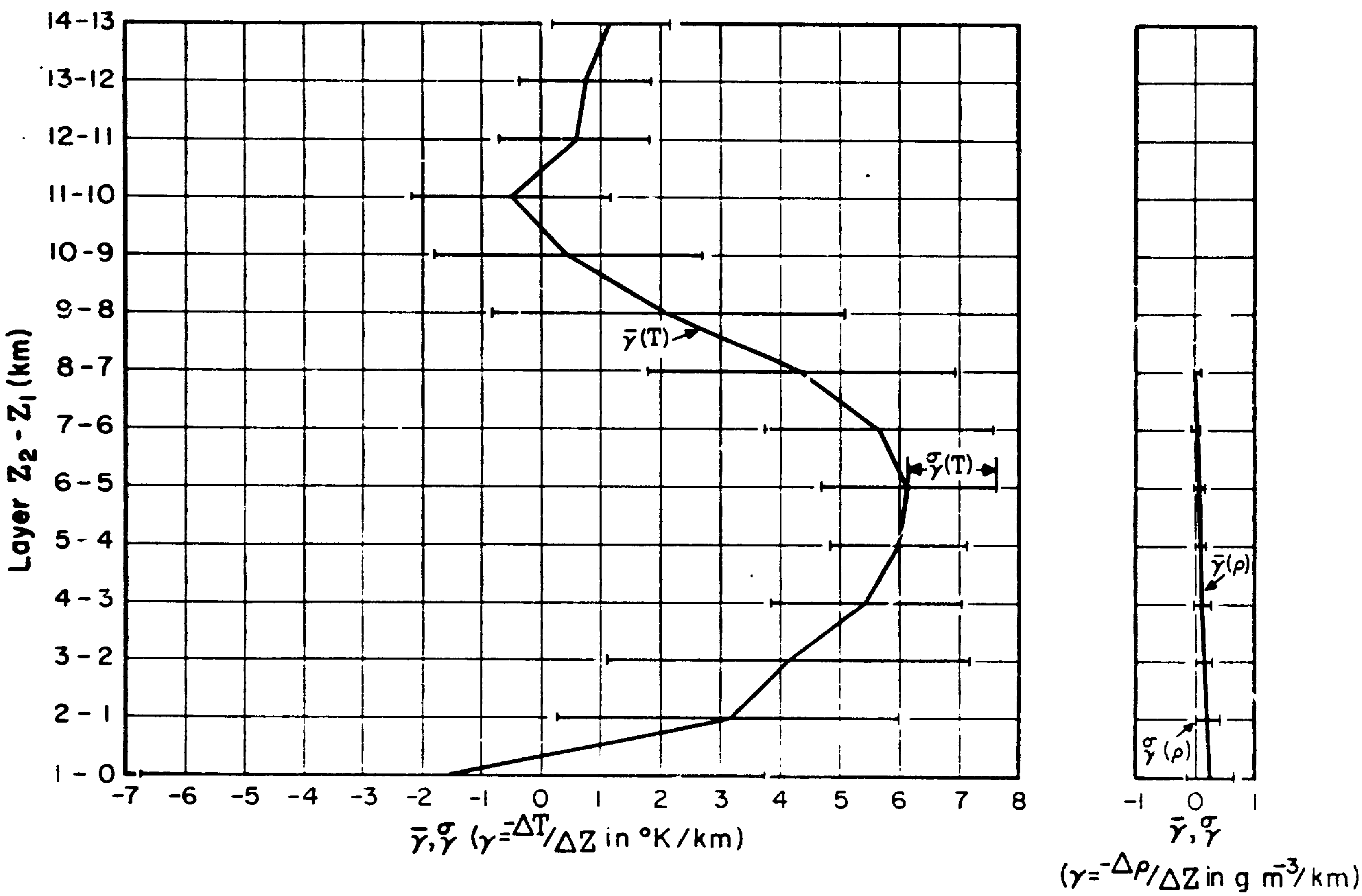


Figure 5-9 The Mean and Standard Deviation of the Lapse Rates of Temperature and Humidity - Thule, Greenland

The method of obtaining profiles of temperature and humidity described in this section produced simulated soundings which closely approximated actual ones for the station and season (winter). This technique produced soundings with a considerable amount of variability, but kept the profiles from oscillating in an unrealistic manner. A further advantage was that by merely adjusting $\overline{\gamma}$ and σ_γ (= 0 for clouds) inversions and clouds in the sounding were accounted for. Samples of the results of this method are shown in Figures 5-10 through 5-12 for each of the three stations.

Although this method yielded the best results of the techniques investigated, it was necessary to go back to the original sounding data (NMC tapes) to obtain values of $\overline{\gamma}$ and α_γ. Since the 4-D model did not contain such sounding data, it was not possible to implement this approach here.

5.4.3 Method Recommended for Simulation Studies

Realistic profiles of temperature and water vapor can be derived from the 4-D model by using an approach which ties the values at all levels to the value at some reference level. In this approach the temperature or humidity value at the reference level is selected by applying a simple Monte Carlo procedure to the mean and standard deviation of the parameter in question. Then the difference of this value from the mean is compared to the standard deviation and a ratio of these two values is computed. For each of the other levels, this ratio is multiplied by the standard deviation at that level and the resulting difference is added to the mean. The computed profile is thus free from the random oscillations described in Section 5.4.1. At the same time, the value found for each level reflects the natural variability at that level, and the shape of the profile is allowed to change.

The reference level selected was the surface. The surface temperature, T(s), and surface water vapor density, $\rho(s)$, were selected by the Monte Carlo process using the means and standard deviation but with the condition that the chosen value lie within one standard deviation of the mean:

$$\overline{T}(s) - \sigma_{T(s)} \leq T(s) \leq \overline{T}(s) + \sigma_{T(s)} \tag{5-1}$$

and

$$\overline{\rho}(s) - \sigma_{\rho(s)} \leq \rho(s) \leq \overline{\rho}(s) + \sigma_{\rho(s)} \tag{5-2}$$

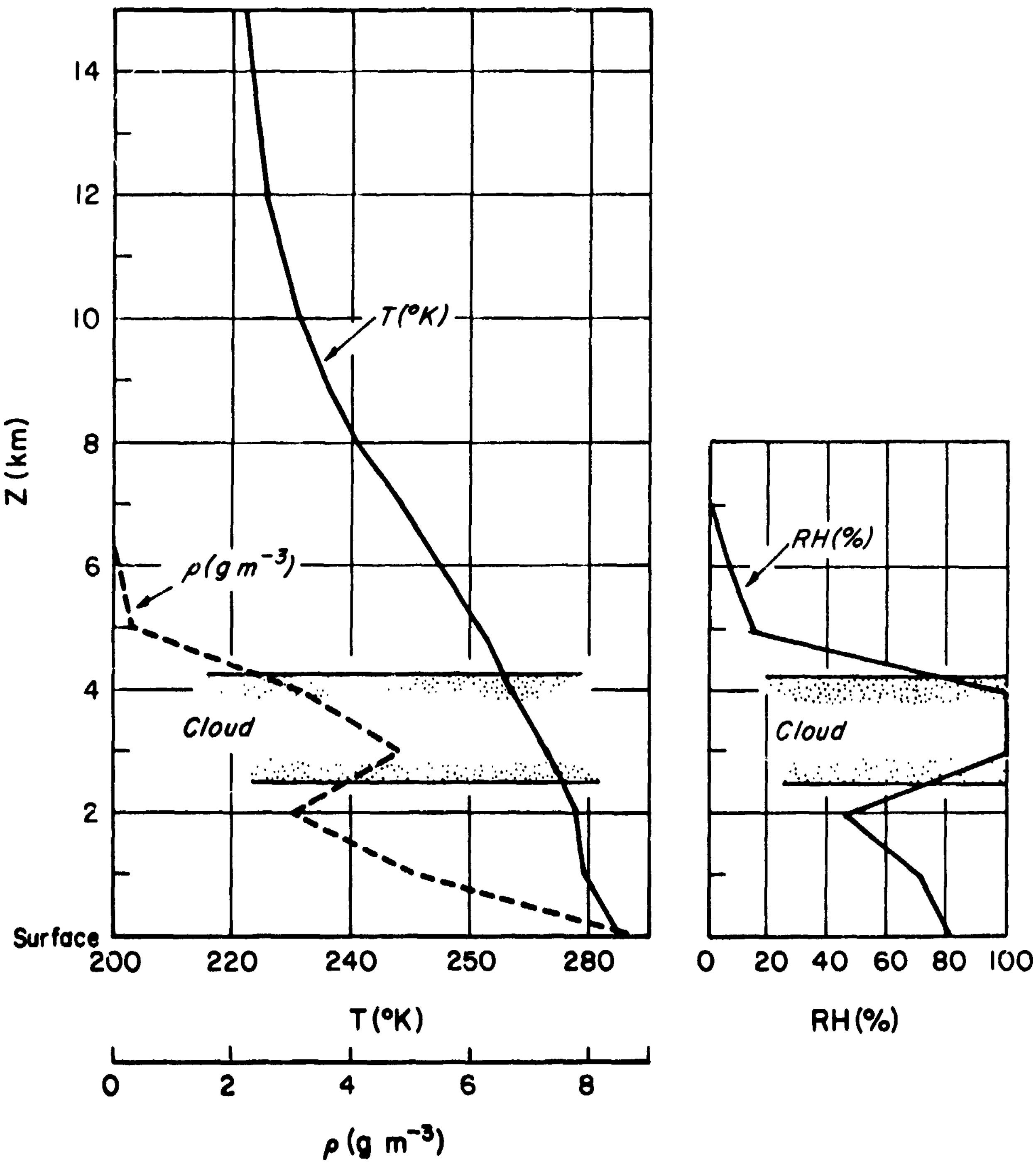


Figure 5-10 Simulated Sounding for Washington, D.C. (Winter, Temperature and Humidity)

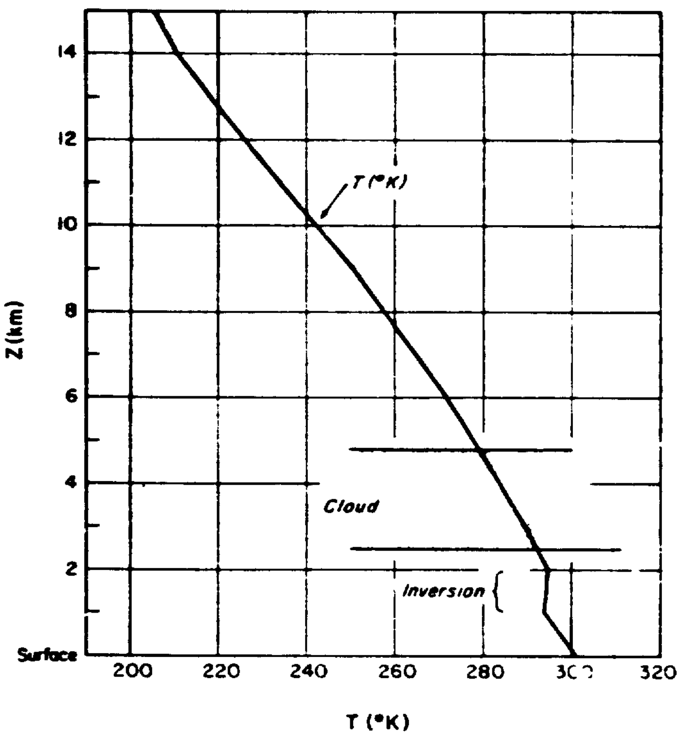


Figure 5-11 Simulated Sounding for Trinidad (Winter, Temperature Only) (Note: Cloud and Inversion Independently Inserted)

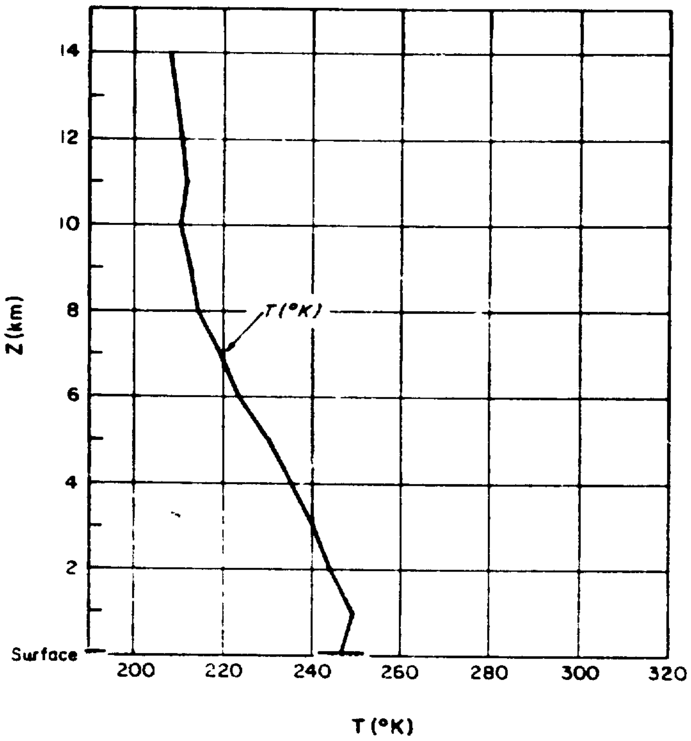


Figure 5-12 Simulated Sounding for Thule, Greenland (Winter, Temperature Only)

where

$T(s)$ and $\rho(s)$ are the selected surface values of temperature and water vapor density

$\overline{T}(s)$ and $\overline{\rho}(s)$ are the mean values of surface temperature and water vapor density

and

$\sigma_{T(s)}$ and $\sigma_{\rho(s)}$ are the standard deviations of surface temperature and water vapor density.

If the conditions in equations 5-1 and 5-2 are not met, the selection process is reinitialized.

Temperatures and vapor density values at other levels are generated on the basis of the percentage of departure of surface values from the mean as compared to the corresponding standard deviation. More precisely,

$$T(i) = T(i) + (R_T)\ \sigma_{T(i)} \tag{5-3}$$

and

$$\rho(i) = \rho(i) + (R_\rho)\ \sigma_{\rho(i)} \tag{5-4}$$

where

$$R_T = \frac{T(s) - \overline{T}(s)}{\sigma_{T(s)}} \tag{5-5}$$

and

$$R_\rho = \frac{\rho(s) - \overline{\rho}(s)}{\sigma_{\rho(s)}} \tag{5-6}$$

with the index i representing values corresponding to the ith level in the atmosphere. The procedure is graphically illustrated in Figure 5-13.

Changes in the profile shape were quite small for the soundings derived from this procedure. This was due to a number of factors. First, all levels had to show an increase, decrease, or no change; it was not possible to have increases in temperature at some levels and decreases at others. This eliminated inversion layers or very steep lapse rates. Also the variability of temperature and moisture tends to decrease with height (with some exceptions) so that most changes were confined to the lower levels. This meant that the derived profiles differed somewhat from the mean profile in the lower layers

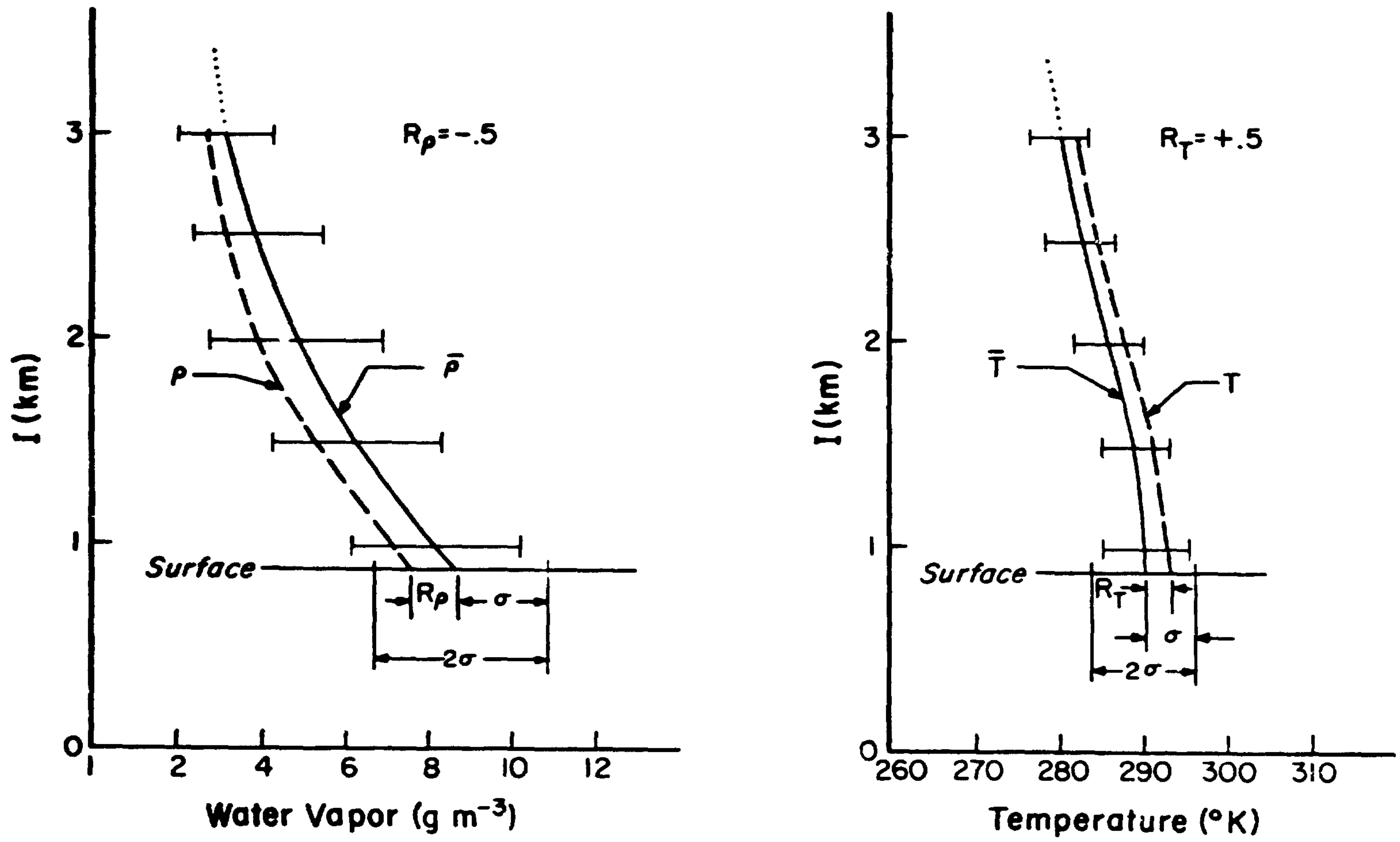


Figure 5-13 Simulated Temperature and Water Vapor Profiles Based on the 4-D Model

but approached the mean at the higher altitudes. Finally, for this experiment, changes were confined to values within one standard deviation of the mean to eliminate extremely unrealistic cases. However, since vertical profiles of temperature and water vapor do tend to assume characteristic shapes, it was not felt that these limitations seriously affected the overall simulation results.

5.5 A Mission Simulation

A test case was devised to simulate atmospheric conditions along the orbital track in the western United States shown earlier in Figure 5-2. This track would represent the subpoint track for a satellite similar to SKYLAB in mission objectives and orbital characteristics. This hypothetical satellite would have as its mission the mapping of the earth's surface with sensors in various wavelength regions, and would have the orbital parameters given in Table 5-5.

The mission observation time increment was selected as 15 seconds to give observations along the track at every 74 n mi. All sensors were assumed to have a 60 n mi. field of view at the earth's surface. This corresponded to the field of view for the cloud statistics and eliminated any problems of overlapping in the observations.

5.5.1 The Simulation Software

The first problem in the simulation was combining the various data banks and parameters into an easily accessible data set. This was accomplished through the use of four programs which placed the data on an IBM 360-75 disk. The first, program A (Figure 5-14) took the mission parameters, processed them through a satellite subpoint generator routine, and output the resulting latitudes, longitudes, times and months in a sequential file on disk.

The second and third programs placed the cloud type, number of cloud layers and cloud cover statistics in random access files on the same disk. The cloud cover statistics included the ground-observed and satellite unconditional statistics and the satellite conditional statistics. The third program (program C in Figure 5-14) for placing the cloud cover statistics in the file has the option to scale the statistics for other than 60 n.mi.

TABLE 5-5

ORBITAL CHARACTERISTICS OF THE HYPOTHETICAL SPACECRAFT

USED IN THE SIMULATION STUDIES

Parameter	Value
Semi Major Axis (Km)	6807.55
Eccentricity	.00165
Nodal Period (minutes)	93.16
Longitude of Ascending Node	121.5° East
Mission Start Time (hour minute second)	122900 LST
Mission Observation Time Increment (seconds)	15
Number of Observations	25
Day	15
Month	5 (May)

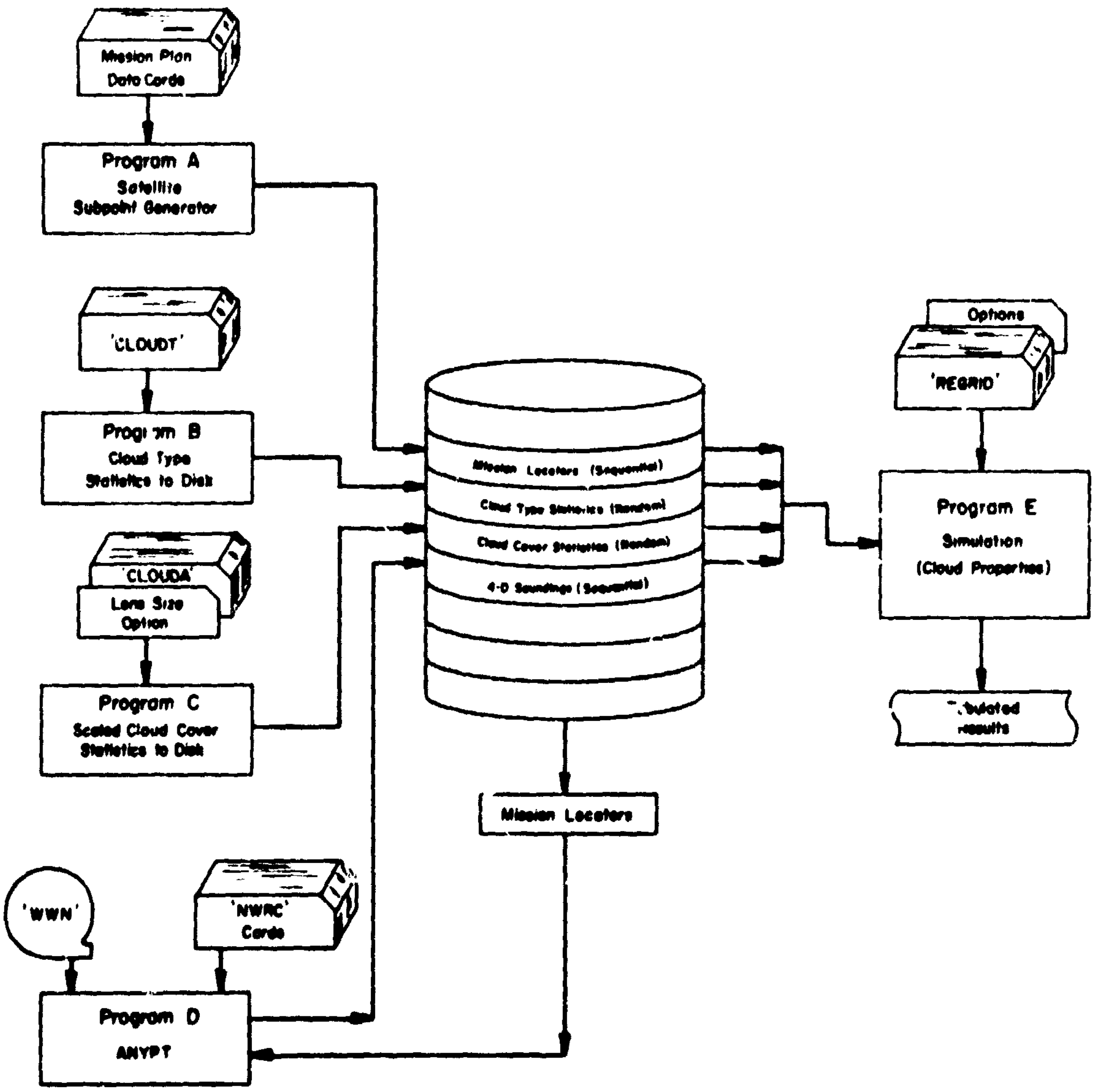


Figure 5-14 Schematic Representation of Simulation Software Utilizing All Data Banks

lens sizes prior to their storage. This option eliminates the need to scale the statistics for lens size in each step of the simulation. Since the field of view in this simulation was 60 n.mi., the scaling option was not put into effect and the statistics were stored in their original form.

Using the fourth program, the mission locators already on disk and the global grid point atmospheric data tapes were input to ANYPT to generate atmospheric profiles unique for each latitude and longitude requested. These profiles were also written on disk in the same order as the mission locators. Each record contained means and variances of temperature, pressure, water vapor and density at every 0.5 km from the surface to 25 km. All records contained statistics for the month of May but each differed slightly in its values due to the spatial changes in this area and due to the highly varied terrain.

With the needed data sets readily and inexpensively available, the simulation program was initialized. The program outlined in Figure 5-15, was quite complex as it used all of the tools developed for simulation, input various options and region cards, and specifed cloud models corresponding to the nine cloud types.

The cloud models used (Table 5-6) are basically the same models given by Chang and Willand (1972). The cumulonimbus, however, is significantly reduced in its liquid water content from the model given by Chang and Willand (1972) since all statistics indicated that the original model was unreasonably wet and could cause drastic errors in any evaluation of integrated liquid water. The other models seemed adequate for a preliminary simulation but will be updated in future runs to use the cloud models proposed in Section 6.

The input cards to the program included REGRID, a data set which specifies the cloud region in which each latitude and longitude point resides; run option cards controlling the amount and types of print output; and a card containing the number of times a mission is to be repeated. In the sample used here, this number was 50 to allow the generation of a statistically valid sampling of liquid water and water vapor amounts. To begin the actual simulation, a mission locator containing a latitude, longitude, month, day, and time was read in from the mission locator file. Subroutine REGNUM was called to compute the region number where the locator resided, and if the locator was the first event in a region, a branch was made to compute the addresses of the cloud type and cloud cover statistics on random access

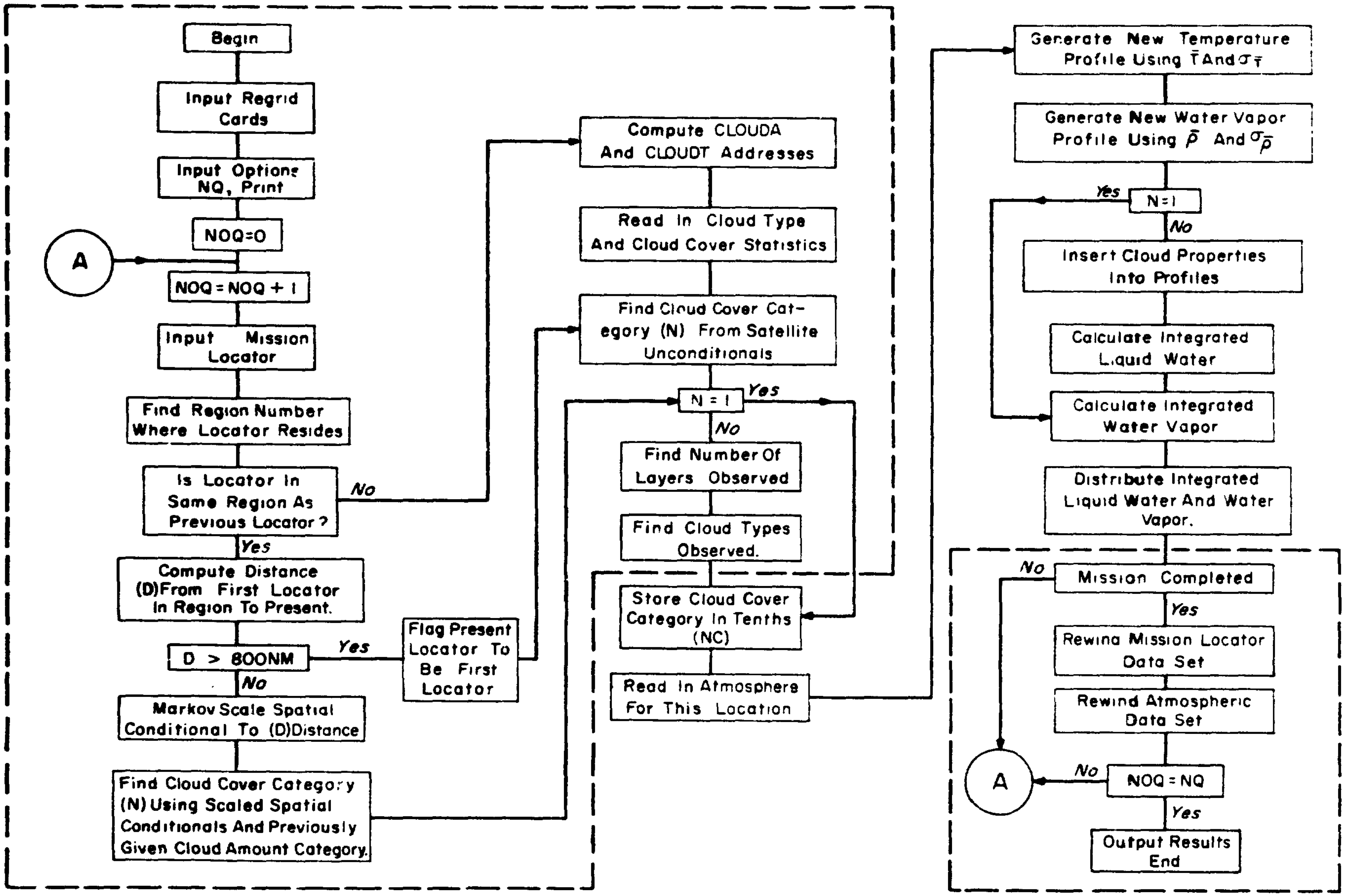


Figure 5-15 A Mission Simulation Scheme

TABLE 5-6

MODELS OF CLOUD PARAMETERS

Cloud Type	Base m(AGL)*	Top m(AGL)*	Modal Radius (μm)	Density or Liquid Water Content (g/m^3)
Cumulus	500	1,000	10.0	0,50
	1,000	1,500	10.0	1.00
	1,500	2,000	10.0	0.50
Stratocumulus	500	1,000	10.0	0.25
Stratus	150	1,000	10.0	0.25
Cumulonimbus	0	300	400.0	0.25
	300	1,000	20.0	0.50
	1,000	4,000	10.0	4.00
	4,000	6,000	10.0	3.00
	6,000	8,000	10.0	2.00
	8,000	10,000	40.0	0.20
Altostratus	2,400	2,900	10.0	0.15
Altocumulus	2,400	2,900	10.0	0.15
Cirrus - Arctic	5,500	6,000	40.0	0.10
- Mid-Lat.	6,500	7,000	40.0	0.10
- Tropical	7,500	8,000	40.0	0.10
Cirrostratus - Arctic	4,000	6,000	40.0	0.10
- Mid-Lat.	5,000	7,000	40.0	0.10
- Tropical	6,000	8,000	40.0	0.10
Nimbostratus	0	500	200.0	1.00
	500	1,000	10.0	2.00
	1,000	2,000	10.0	3.00
	2,000	4,000	10.0	2.00

*AGL = Above Ground Level

data sets corresponding to the region, time and month of the event (in this experiment the time used was 1300 LST). The statistics for the first event in the region were then read in and stored. In a similar manner, a new 4-D atmosphere was read and stored whenever a new moisture region was indicated.

When the locator was other than the first event in the region, its distance D in nautical miles from the first event in the same region was computed. If the computed distance was greater than 800 n.mi., a branch was made to the satellite observed cumulative unconditional statistics to determine the cloud amount. Otherwise the spatial cloud amount probabilities were scaled to a distance D by using the MARKOV scaling routine, and the resulting scaled probabilities were summed to form cumulative probability tables. A new cloud amount category was then determined using the amount category observed in the previous event together with a newly drawn random number, and the newly aled cumulative probabilities.

In the cases when the cloud cover category did not equal 1 (1 represents clear sky), the program found the number of cloud layers observed using a newly drawn random number, and the cloud layer statistics. From the number of layers observed, the cloud type statistics were then utilized to determine cloud types. Finally, the cloud amount category was converted to tenths of cloud cover and stored for future use. If the cloud category equalled 1 (clear sky), the above procedure was skipped and the cloud cover amount was set equal to 0.

In this simulation the primary variables of interst were the total integrated water vapor ρ, and the total integrated liquid water (W) found over each subpoint in the mission. The integrated liquid water was dependent solely on the cloud models selected; however, profiles of temperature and water vapor had to be derived from the 4-D model. (The 4-D model parameters of pressure and density were considered of little importance in this example.) The method for simulating profiles of temperature and moisture was described in Section 5.4.3 and was implemented as follows.

An IBM subroutine called GAUSS was modified to select surface values of temperature and moisture using the mean and standard deviation of the parameters. One standard deviation was used to eliminate questionable values of the atmosphere that may fall two or three standard deviations from the mean. Utilizing the modified version of subroutine GAUSS and equations 5-5 and 5-6, the temperature and water vapor values at each level were computed. The new water vapor values at each level were then compared with the computed saturated water vapor to insure that they were not supersaturated. If supersaturation occurred, the water vapor value at level i was replaced by the saturated value and multiplied by .9. This procedure insured an unsaturated atmosphere in the absence of clouds.

The previously simulated cloud data were then inserted into the profiles at heights (tops and bottoms) in accordance with the data contained in Table 5-6. At every level for which cloud is present, the program forces the atmosphere to become saturated by modifying $\rho(i)$ and keeping $T(i)$ constant. Intermediate levels were inserted for all parameters when the base of a cloud layer did not correspond to a preexisting atmospheric level. In many cases, the surface height was added to the heights given by the cloud models prior to their insertion, since clouds tend to occur at standard heights above the earth's surface, not at standard heights above sea level.

Figure 5-16 provides two examples of the results of this simulation technique. The first, profile A, show temperatures higher than the mean temperatures and extremely high values of water vapor and liquid water. This case represents the conditions associated with a large cumulonimbus, and its similarity to observed values for such conditions is clear. The second set of profiles shows a clear sky case for the same location. Here the values are very close to the mean value. The small departure from the mean is not specified as characteristic of cloudless skies, rather, it reflects the use of the random number process which selected a small temperature departure here and a large one for the severe storm case.

From these profiles the total integrated water vapor and liquid water are computed, and the integrated liquid water value is then modified by the tenths of cloud cover observed. The gross assumption made here was that the amount of water corresponding to 8/10 of cloud cover in the field of view is sensed by the satellite as:

$$M = A\,(C \cdot W + (1-C) \cdot D) \qquad (5\text{-}7)$$

where

M = the amount of liquid water sensed (g)

A = the area in the field of view (cm^2)

C = the amount of cloud cover in tenths

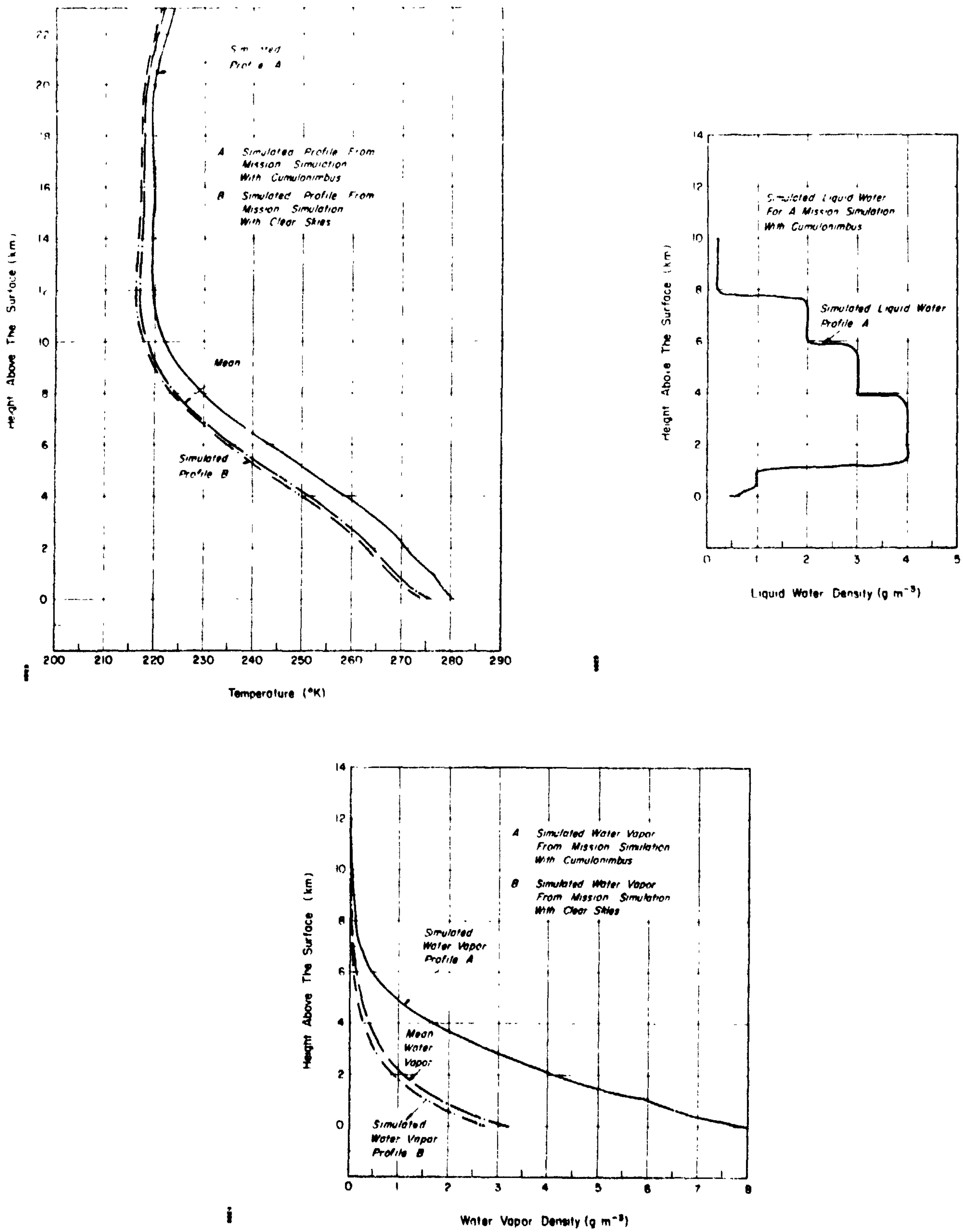


Figure 5-16 The Mean and Simulated Profiles for Temperature, Water Vapor and Liquid Water - Region 13, Month 5, Point 1

W = the amount of liquid water in a unit area of cloud ($g\ cm^{-2}$)

D = the amount of liquid water in a unit area of clear sky ($g\ cm^{-2}$)

Since the amount of liquid water in the clear sky area is 0 by definition, this equation reduces to:

$$M = A \cdot C \cdot W \tag{5-8}$$

If M is divided by the area, to obtain an average integrated liquid water for the field of view, the liquid water content for a unit area is simply the integrated liquid water multiplied by the tenths of cloud cover. For example, 8/10 cloud cover would result in an average liquid water content equal to .8 of the integrated liquid water computed from the sounding. This concept requires further investigation to determine if it actually reflects remote sensing conditions. However, it does provide a preliminary method for scaling the integrated liquid water in a cloud the amount of cloudiness observed.

Upon completion of the simulation of atmospheric conditions over the 25 points in each mission, the data sets for mission locators and the atmospheric profiles were rewound. The mission repeater counter was tested against the number of missions requested to see if the simulation was completed. If not, the counter was incremented and the simulation was repeated. On completion of all the missions, the arrays containing the water vapor and liquid water categories were printed, as were the computed probabilities of occurrence of the values in each category. A summation of the performance of the entire mission was also computed and output.

5.5.2 Results of the Mission Simulation

The results of the above simulation are presented as normalized frequencies of occurrence of selected water vapor and liquid water categories. The percentages of cloud cover determined by this simulation are not given here since simulation of this parameter has previously been demonstrated. The frequencies are based on the simulation of fifty passes over the same suborbital track at a fixed hour during one month (May). Since the cloud statistics are stratified by month, these passes all used the same basic statistics which greatly simplified the running of the program while not seriously biasing the results.

Examples of the frequency of occurrence of the various categories of water vapor and integrated liquid water are shown for points 8 and 24 (see Figure 5-2) in Figures 5-17 through 5-20. The categories used for integrated water vapor represent a fixed range of 0.25 g cm^{-2}, but those used for integrated liquid water are variable representing 0.025 g cm^{-2} from 0 to 0.1 g cm^{-2}, 0.1 g cm^{-2} from 0.1 to 1.0 g cm^{-2} and 1 g cm^{-2} for a higher value. This variability was necessitated by the concentration of most total liquid water contents in the range from 0 to 0.1 g cm^{-2} but the occasional occurrence of cumulonimbi with much higher values. The frequencies for the liquid water categories are plotted against the logarithm of the water content with an χ added to indicate the frequency of clear skies (zero liquid water).

Isopleths of the frequencies of occurrence of the water vapor and liquid water categories for the entire simulation are shown in Figures 5-21 and 5-22 as is the profile of the surface elevation along the suborbital path. The categories are the same as those used in Figures 5-17 through 5-20 but the frequencies have now been analyzed to indicate increments of 0.10. Thus the value of 0.16 given at point 24 for the water vapor category 0.75 - 1.0 g cm^{-2} in Figure 5-17 is anlayzed in Figure 5-21 as lying between 0.10 and 0.20. On the other hand, Figure 5-5-22 indicates that the frequency of liquid water content in the range of 0 - 0.025 g cm^{-2} over point 10 is greater than 0.30. Figure 5-18 specifies 0.34. Some accuracy is lost in this method of analysis but it does provide an excellent summary of the frequencies found along the entire suborbital track.

The water vapor plot shows the desired correlation with climate and elevation. The values for the first seventeen points are associated with locations in the Oregon, Idaho, Utah, and Colorado mountain ranges with the highest elevations found for the mountains in New Mexico. The water vapor for this area shows its highest frequencies in the lower water vapor categories reflecting the cool climate found there in May. On the other hand, a very sharp increase in the frequencies of high integrated water vapor is found when the suborbital tract crosses into Texas. By May, hot, humid air has usually pushed its way north into the panhandle. This not only causes high values of integrated water vapor; it also sets up a very sharp gradient between the plains and the hills just a short distance to the northwest.

In the moisture regions defined for the 4-D models these two areas fall into entirely separate regions. The first points are all included in Region 28 (low average moisture, border of mountain range) or in Region 27 (very low average moisture, major mountain range). Northern Texas, however, falls into Region 13 which is described as midlatitude continent with moderate average moisture (Spiegler and Greaves, 1971). The support of these classifications found here is encouraging. The values, unfortunately, appear slightly high in comparison with frequencies found for these regions (Spiegler and Fowler, 1972), probably due to the saturation specified in cloud layers. This indicates the necessity of further examination of the correlation between water vapor and cloud layers, and future refinement of the technique of cloud insertion.

The frequencies of integrated liquid water do not show such a well defined spatial distribution. However it is clear that the points located in Regions 30 and 19 (points 16-25) have a high frequency of clear skies or low amounts of cloudiness with 60 to 80% of the liquid water contents reported for these areas less than or equal to 0.25 g cm^{-2}. On the other hand, Region 8, in the peak of its severe storm season, shows a 15-20% frequency of thunderstorms. (Liquid water contents of greater than 0.4 g cm^{-2} are probably caused by the cumulonimbus model.) Comparison of these statistics with the unconditional statistics for 1300 LST explains these differences. The probability of a thunderstorm in Region 8 in May is 18.2% (Chang and Willand, 1972) while the probability of clear skies in Region 30 is 38% (Chang it al, 1973). Thus the cloud type statistics appear to be well reproduced.

Figure 5-22 points up one of the problems with the cloud models - lack of variability in liquid water amounts. Under normal atmospheric conditions, the liquid water contained by a cloud would not suddenly jump from 0.2 g cm^{-2} to 2 g cm^{-2}. It would show a gradual increase as the cloud grew in height and density. This growth is not duplicated here. The clouds appear to be either shallow and not very wet, or giant severe storms. The models proposed in Section 6 will hopefully alleviate some of this problem. High probabilities of low liquid water content will always be expected, but certainly higher probabilities of moderate liquid water and lower probabilities of high liquid water content would be more realistic.

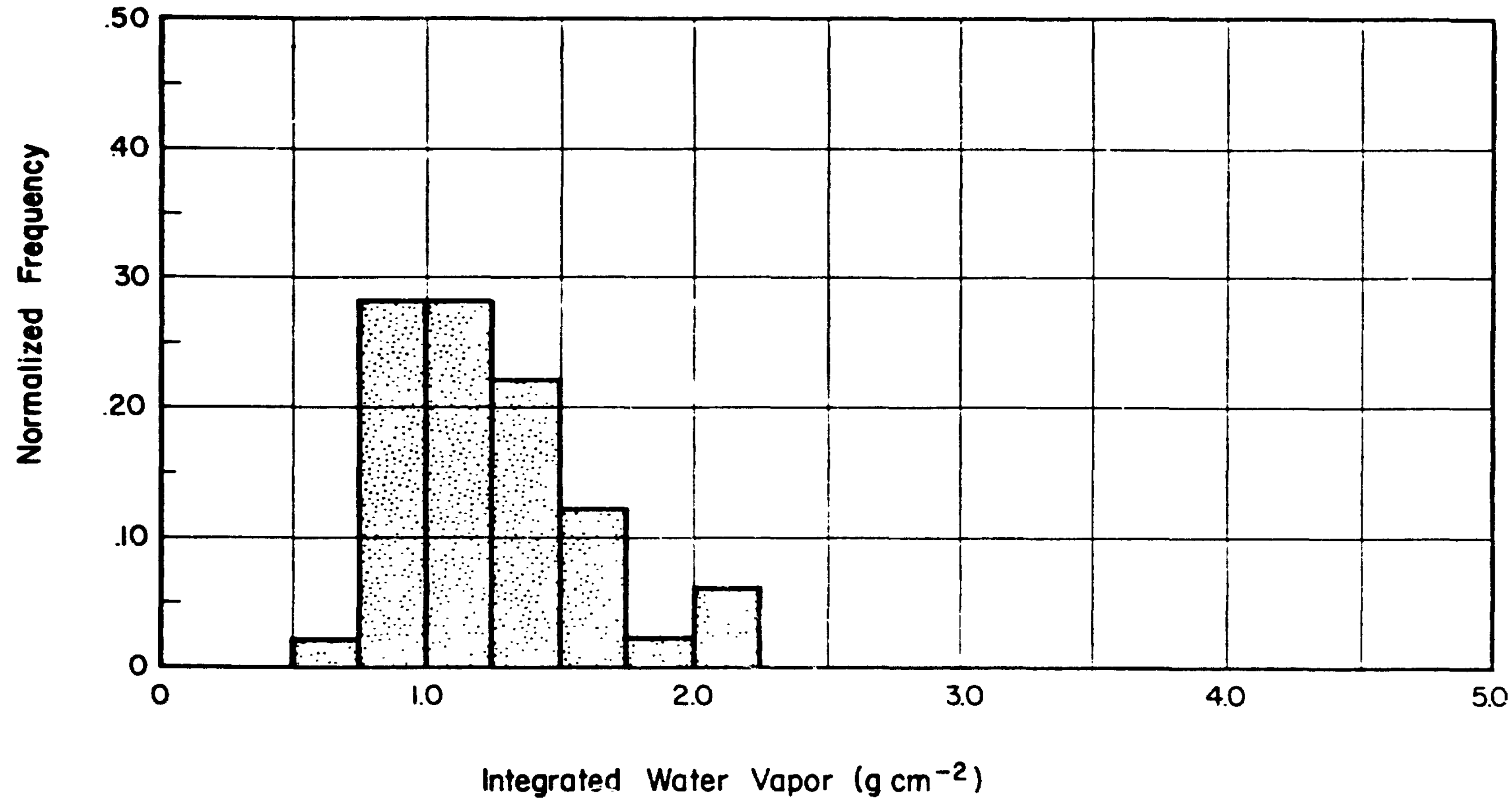


Figure 5-17 Simulated Water Vapor Frequencies - Region 8, Month 5, Point 10

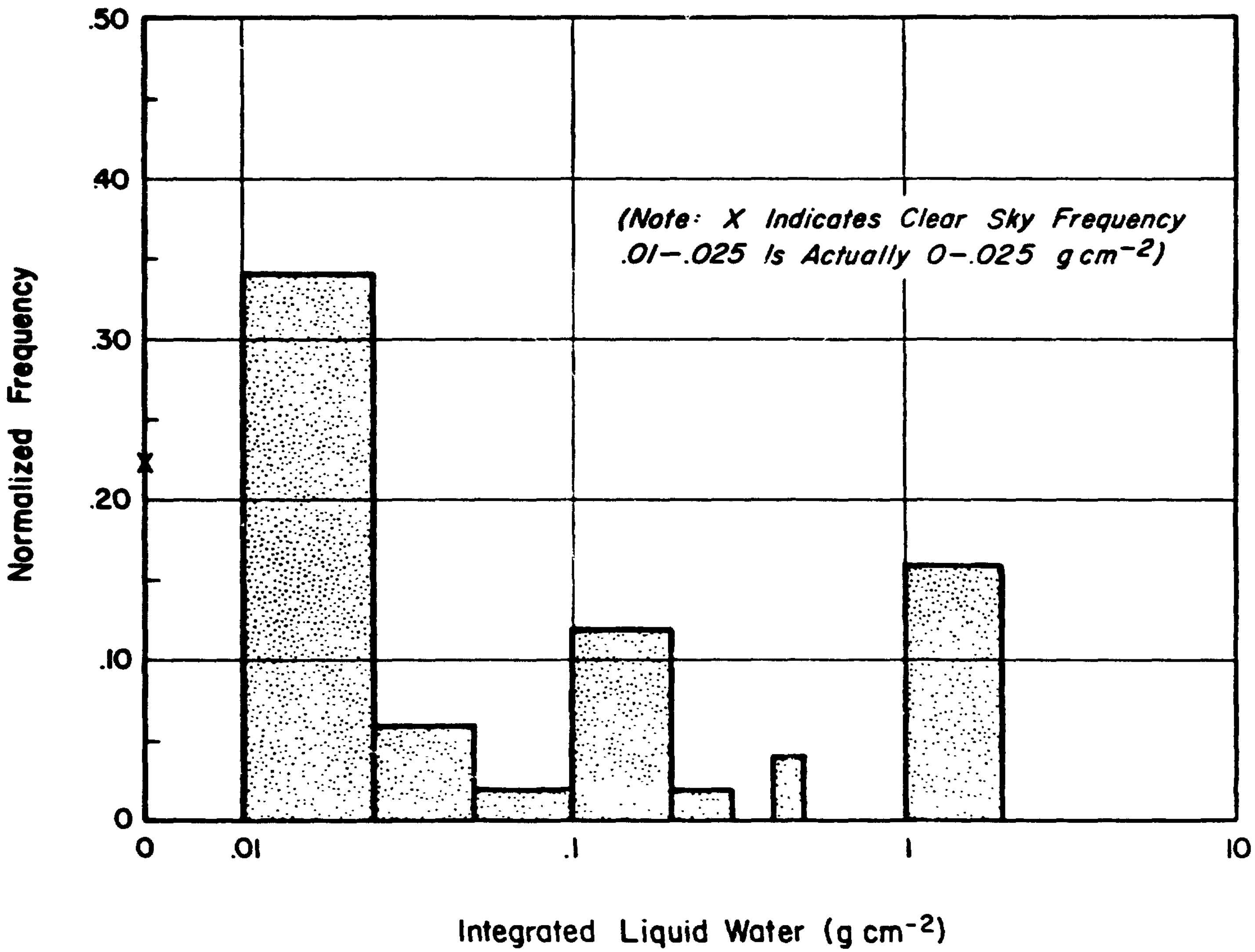


Figure 5-18 Simulated Liquid Water Frequencies - Region 8, Month 5, Point 10

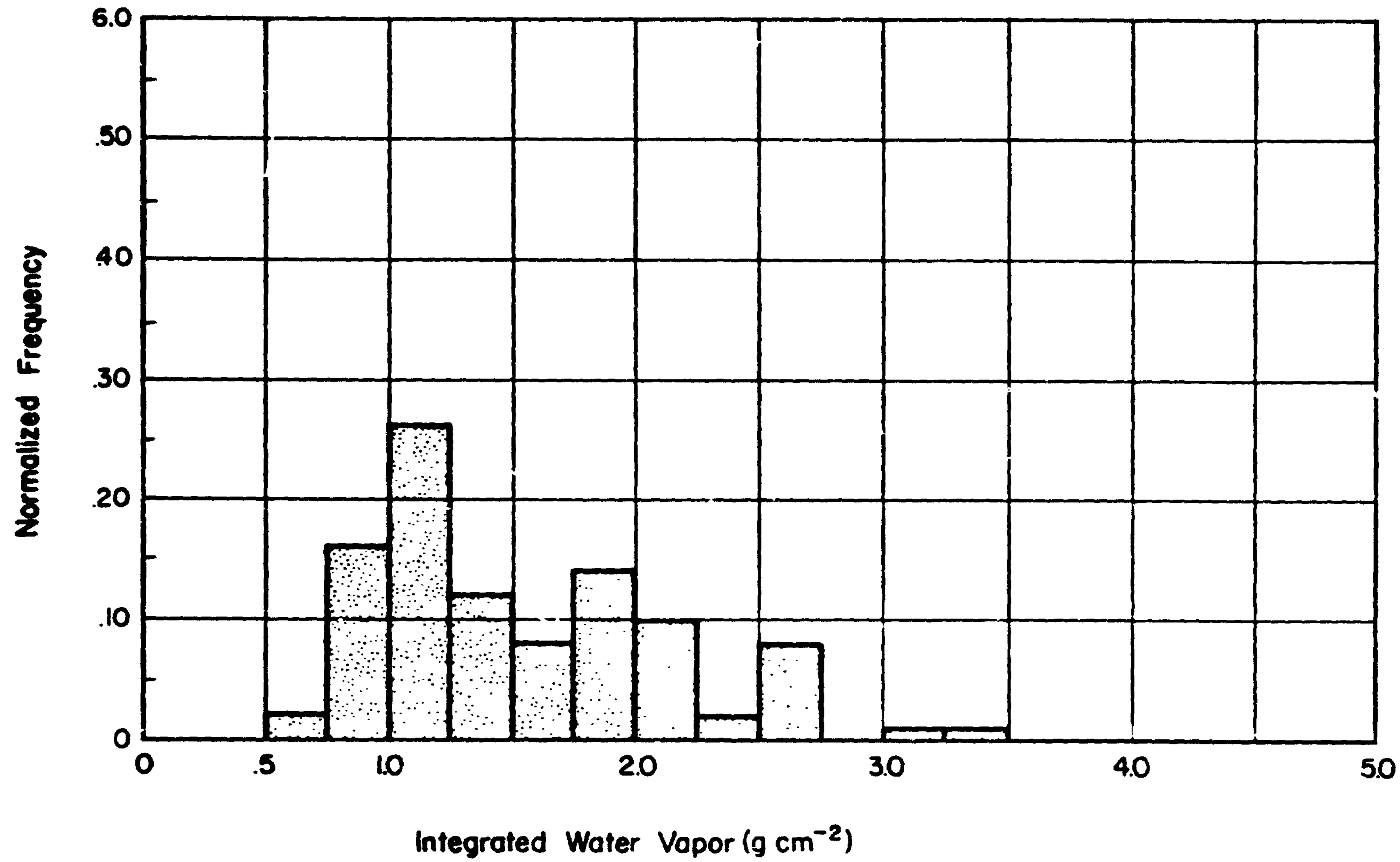


Figure 5-19 Simulated Water Vapor Frequencies - Region 30, Month 5, Point 24

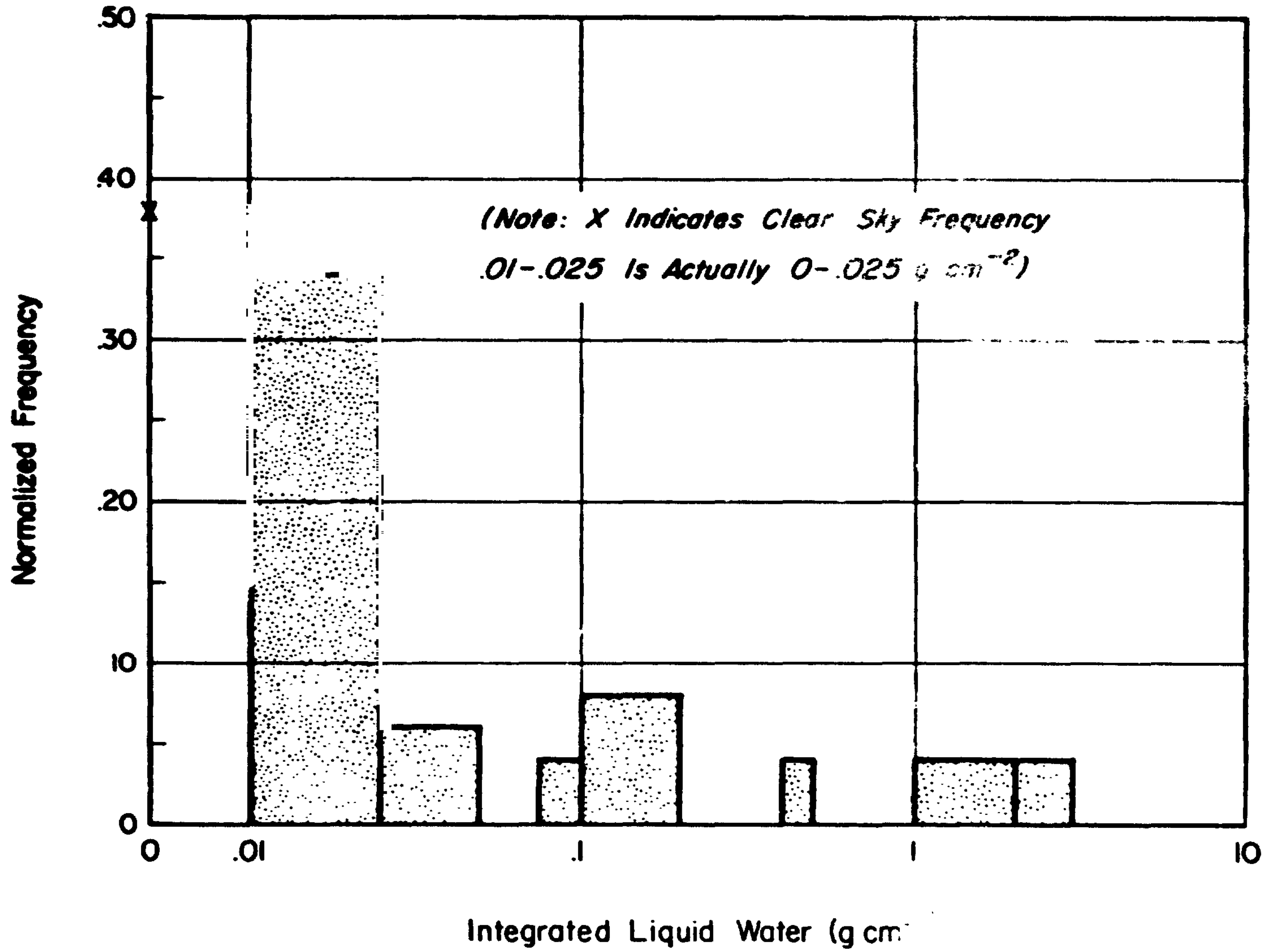


Figure 5-20 Simulated Liquid Water Frequencies - Region 3?, Month 5, Point 24

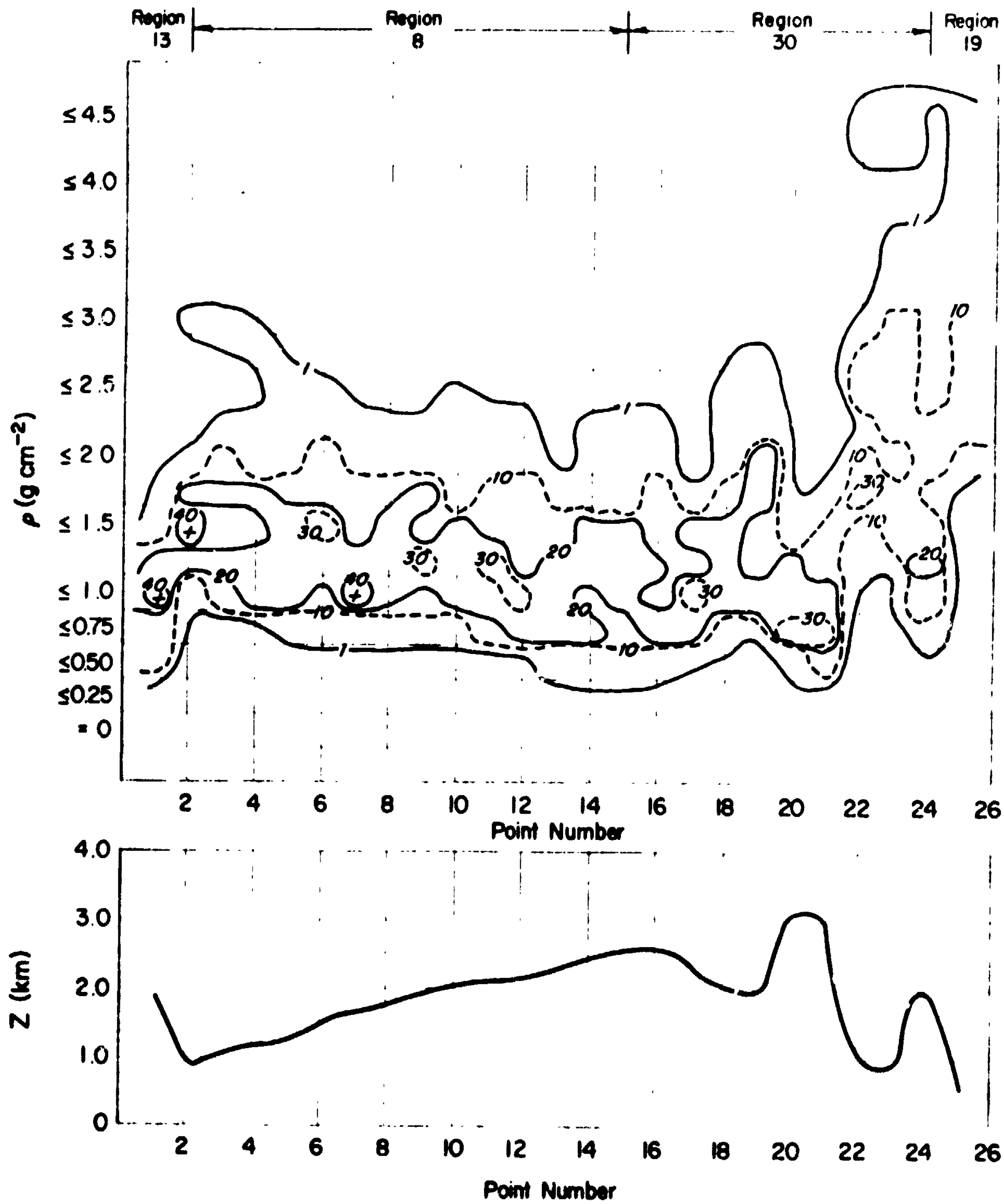


Figure 5-21 Simulated Water Vapor Frequencies for the Mission Simulation Sub-Point Track. Bottom figure shows approximate topography along the track.

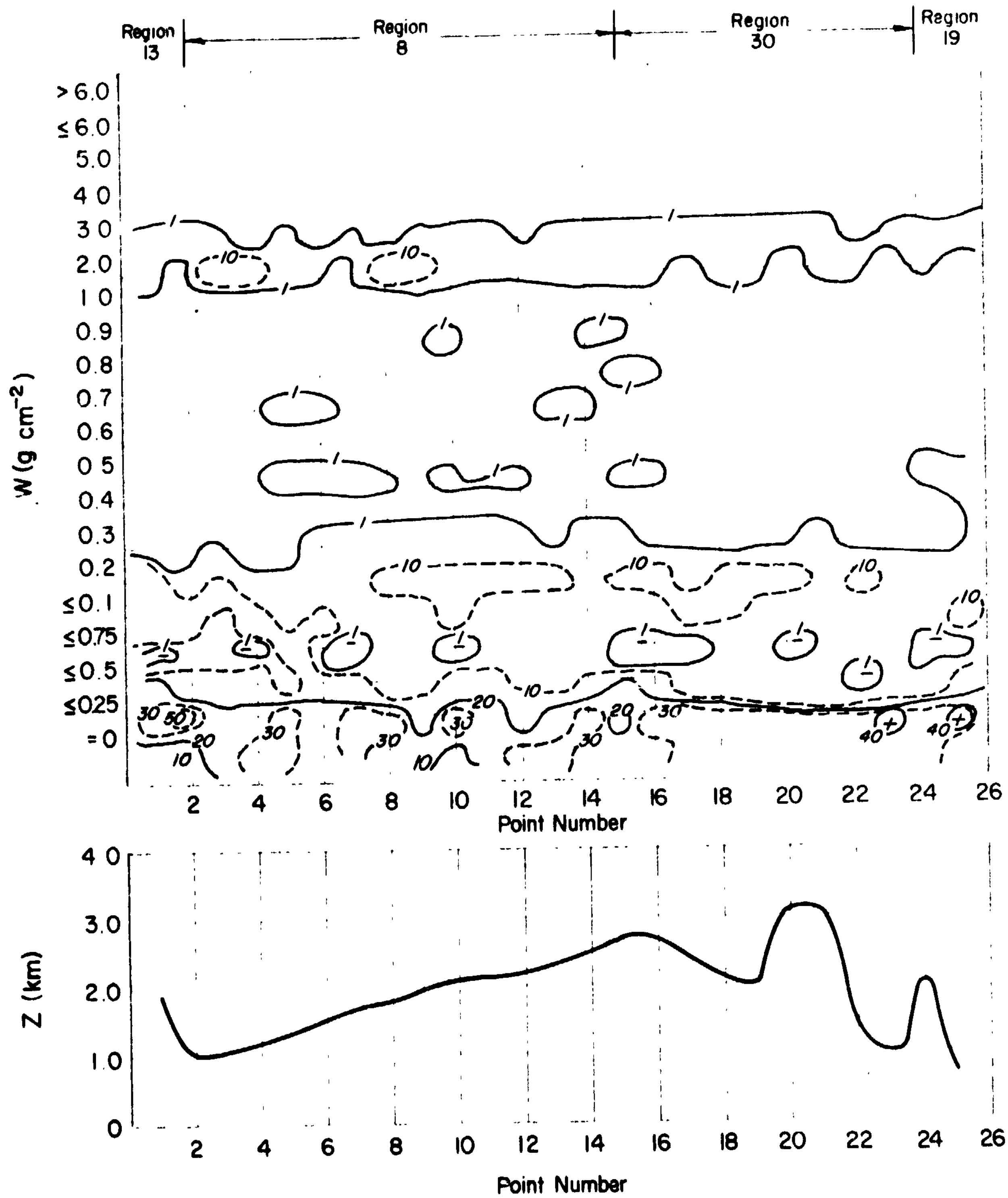


Figure 5-22 Simulated Liquid Water Frequencies for the Mission Simulation Sub-Point Track. Bottom figure shows approximate topography along the track.

Ignoring these problems with the absolute values resulting from the simulation, it is possible to see the usefulness of the results. For example, if a microwave sensor was to be used which would saturate at more than 0.1 g cm^{-2} of liquid water, but would provide good data when less water was present, the statistics would indicate a 68-74% likelihood of success over points 10-12 and a 79% likelihood of success over the entire path (Figures 5-23 and 5-24). On the other hand, any sensor seriously contaminated by water vapor amounts greater than 0.5 g cm^{-2} would be virtually useless for any study of the earth's surface along this suborbital track. The possibilities for simulations and investigations are endless. This is only one hypothetical case to test the simulation tools available.

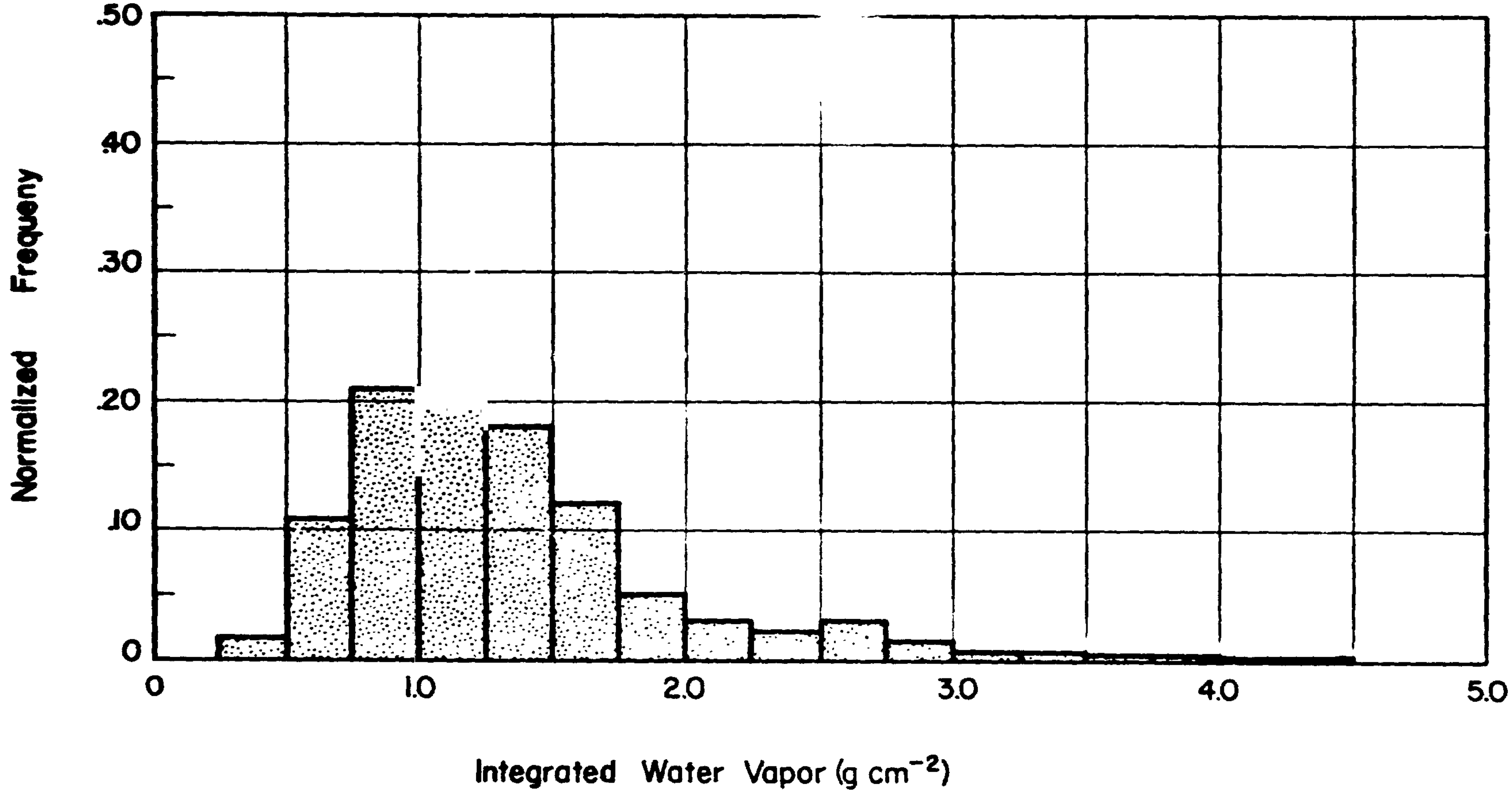


Figure 5-23 Average Water Vapor Frequencies for the Entire Mission Simulation

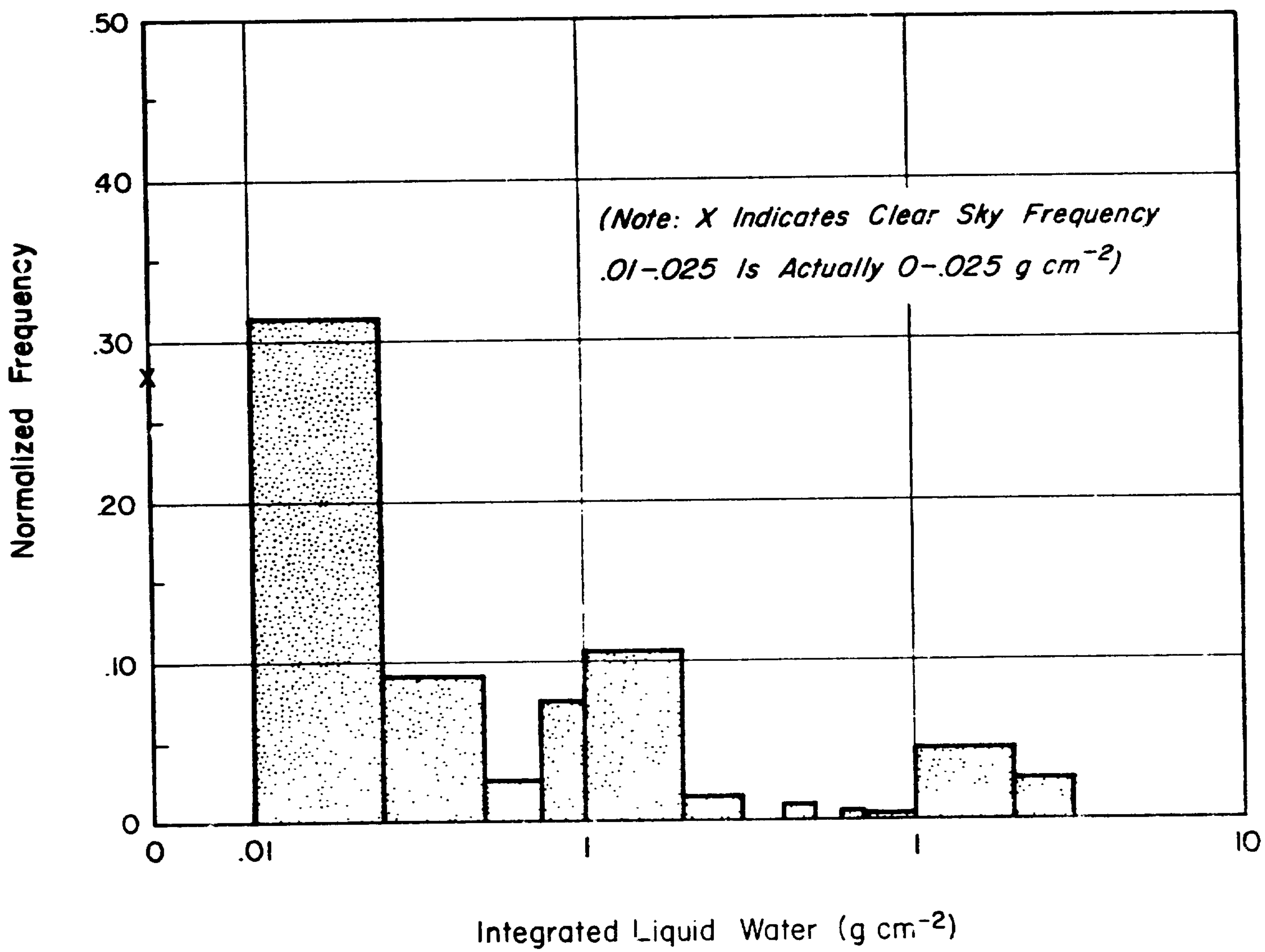


Figure 5-24 Average Water Vapor and Liquid Water Frequencies for the Entire Mission Simulation

6. PROPOSED CLOUD MODELS FOR MISSION SIMULATION

The nine cloud models used in the mission simulation presented in Section 5 were developed by Chang and Willand (1972). The models provide a good first estimate of the parameters appropriate to the cloud types given in the data banks; however, they are somewhat limited in altitude, high in liquid water content and model droplet radius, and too specific to reflect the varied conditions represented by the cloud statistics. The integrated liquid water frequency distributions derived in the simulation reflected these limitations. Many very low values were reported, as were a significant number of high values, yet very few liquid water values were found between these extremes. Such a frequency distribution was clearly unrealistic.

To permit a better representation of the cloud types used in the simulation, a detailed study was made of in-cloud parameters. This study concentrated on two main areas: an extensive literature search, and a careful analysis of recent cloud droplet measurements. The sources encountered in the literature search are listed in Section 8. They were used primarily to provide a summary of the information available on cloud liquid water content and droplet distributions, and thus to evaluate existing cloud models and provide a basis for improved models.

Since the cloud characteristics indicated by the literature search were based on a wide variety of instruments, sampling many different cloud types in all corners of the globe, it was felt that a consistent data set might provide a better guide to variations between cloud types. Such a data set was available from the measurements made by a laser cloud particle spectrometer flown on NASA's Convair 990. This nephelometer sized and counted droplets from which droplet distributions, droplet densities, and liquid water contents could be deduced. Its findings have been presented by Blau, et al, (1972) and Fowler, et al, (1973), and include 2,000 samples collected over the Pacific and the Caribbean, and 1,200 samples collected over the Bering Sea. During this study, these samples were used to produce statistics of in-cloud parameters representing various stratiform and cumuliform clouds. Combined with the statistics resulting from the literature search, these values provide the basis of the proposed cloud models.

Table 6-1 presents the cloud models proposed to represent the nine cloud types. In many ways they are similar to those shown in Table 5-6, but the inclusion of a standard deviation for each parameter makes them for more sensitive to natural atmospheric variability and far more useful in mission simulation.

Gaussian distributions are assumed for all parameters. The selection of a specific cloud thickness, liquid water content, or other parameter, for a simulated situation can thus use a Monte Carle technique based on a normal distribution defined by the mean and standard deviation of that parameter. Non-negative numbers are not permitted; when such a number is indicated, a new value should be selected which still lies below the mean. Selecting individual cloud models in this fashion, should reproduce both the frequently occurring, representative clouds, the extremely thick, wet clouds, and the rather insignificant little clouds.

In the cloud models where more than one layer is specified, it is expected that the thickness of the lowest layer will be selected first, and the cloud layer top thus defined would be used as the base for the second layer. If necessary the same procedure would be followed to assign the base of a third layer.

The cumulus model combines features of cumulus humilis and cumulus congestus, since statistics for cumulus represent both cloud types. Hence considerable variability is found in the parameters for this cloud model. Since cumulus is a highly variable cloud type, it is felt that the statistics given here permit a good recreation of atmospheric conditions. Likewise, the cumulonimbus shows large standard deviations. In height this cloud type ranges from 4 km to 20 km and its in-cloud concentrations of liquid water show considerable spatial variation corresponding to the large natural variations found in thunderstorms. On the other hand, very limited variability is indicated for stratiform clouds since most observations show widespread spatial and temporal homogeneity in the structure of these clouds.

The proposed models are only preliminary, requiring both further research on cloud droplets and the inclusion of information on ice and rain layers. However, it is felt that they generally reflect the microstructure of the various cloud types included in the global cloud data set, and allow a good estimate of the conditions likely to be encountered during satellite missions. The inclusion of statistics on the variability of the in-cloud parameters is considered an especially important feature of these models permitting, for the first time, realistic simulations of cloud microstructure.

TABLE 6-1

PROPOSED CLOUD MODELS

Cloud Type	Base (m)		Thickness (m)		Liquid Water Content (gm^{-3})			Radius (μm)			Droplet Density (no. cm^{-3})			Composition
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Maximum	Mean	Standard Deviation	Maximum	Mean	Standard Deviation	Maximum	
Cumulus	500	150	500	150	.10	.20	1.00	5.5	1.0	25.0	30	50	200	Water
	1000	150	3000	800	.50	.50	3.00	8.0	2.0	50.0	70	70	300	Water
	4000	800	500	150	.10	.10	.50	6.5	1.0	40.0	30	20	100	Water
Stratocumulus	300	150	2000	500	.20	.20	.80	4.5	1.0	50.0	100	100	500	Water
Stratus	150	100	1000	300	.15	.15	.80	5.0	2.0	30.0	150	100	500	Water
Cumulonimbus	500	150	500	150	.10	.20	1.00	5.5	1.0	25.0	30	50	200	Water
	1000	150	9000	2000	1.00	1.00	5.00	10.0	1.0	50.0	70	70	300	Water
	10000	2000	2000	500	.10	.10	.50	40.0	10.0	200.0	1	1	5	Ice
Altostratus	2000	500	4000	500	.15	.15	.70	6.0	0.6	20.0	70	30	175	Water
	6000	500	4000	1000	.02	.02	.10	40.0	10.0	200.0	10	15	70	Ice
Altocumulus	2000	150	5000	500	.15	.15	.50	4.8	0.5	20.0	30	30	100	Water
Cirrus Arctic	4000	300	2000	500	.005	.005	.03	20.0	10.0	100.0	1	.5	2.5	Ice
Midlatitude	6000	300	3000	500	.005	.008	.05	40.0	10.0	200.0	.8	1	5.0	Ice
Tropical	8000	300	4000	500	.005	.02	.07	40.0	10.0	200.0	.5	2	10.0	Ice
Cirrostratus Arctic	4000	300	3000	500	.005	.005	.03	20.0	10.0	100.0	1.0	.5	2.5	Ice
Midlatitude	6000	300	4000	500	.005	.008	.05	40.0	10.0	200.0	2.0	1.0	5.0	Ice
Tropical	8000	300	5000	500	.005	.01	.07	40.0	10.0	200.0	0.5	2.0	10.0	Ice
Nimbostratus	1000	300	3000	500	.10	.10	.50	5.0	0.5	20.0	70	30	175	Water

7. PLANNED MODIFICATION OF THE 4-D MODEL

The 4-D atmospheric model contains monthly means and variances of pressure, temperature, water vapor and density at 1 km intervals from the surface to 25 km. These values are given in two data sets. The first contains statistics for 45 homogeneous moisture regions covering the globe while the second provides grid point values for the NMC grid and at every 5° latitude-longitude point between 20°N and the south pole. Both data sets are associated with programs which permit the selection of atmospheric profiles for any latitude and longitude on earth.

An example of the usefulness of these data sets was presented in Chang and Fowler (1973) where atmospheric water vapor and infrared transmission predicted by the region mean profiles were compared with the values predicted by the zonal standard atmospheres (U. S. Standard Atmosphere Supplement, 1966). There the greater detail provided by the region data showed climatic and radiational differences not apparent from the standard atmospheres, while not significantly increasing computational difficulties.

In Section 5 of this report, a mission simulation procedure was tested which not only used atmospheric statistics unique to each location but also varied these to get profiles unique to each event, and to allow the realistic insertion of clouds. Thus the value of these data sets in studies of the hydrodynamic, thermodynamic, and radiative properties of the atmosphere has been well demonstrated.

However, it has long been felt that the other major atmospheric parameters, the wind speed and wind direction, should be added to the data sets. Although winds do not directly affect the remote sensing of the earth's surface, they are important in the evaluation of many problems. In missile reentry studies winds are of prime importance since very strong winds could alter the course of the missile or cause undue stress and damage the missile. Simulation of missile reentry thus requires a good knowledge of the winds that might possibly be encountered, and it requires this knowledge on a global and temporal scale such as that used by the 4-D model.

Detailed wind statistics are also important in predicting the spatial and temporal variability of cloud conditions. Although good statistics are now available on cloud cover conditionality, additional information might be gained from data on the wind fields, especially on the joint spatial and temporal variability. If frontal conditions are indicated by a simulation, and the winds at 200 mb are also given, it might be possible to determine the speed and direction at which the frontal system is moving and thus to specify cloud conditions at a given time and distance away. Advection of different air masses could also be simulated to predict temperature and moisture changes, and thus to more precisely specify profiles of these parameters. Furthermore, estimation of the wind fields from space observations of cloud cover could be greatly assisted by statistics on the winds in the area. For these reasons, and others, it has been decided to add means and variances of wind speed and direction to the 4-D model. Section 7.1 will present the anticipated approach.

It was also decided to extend the 4-D model to 50 km and to do this jointly with the addition of the wind statistics. Information at such altitudes was not felt to be important for the original 4-D model since the model was developed primarily to provide data on atmospheric water vapor. This gas exists only in very small amounts over 10 km, and is virtually a trace gas above 25 km. Thus, simulation of atmospheric attenuation due to water vapor rarely requires atmospheric data above 25 km. Attenuation in various wavelengths due to other parameters such as the temperature-dependent oxygen also can be well simulated by models which only extend to 25 km. And atmospheric studies of the troposphere, and thus of most weather events affecting the earth's surface, can certainly be done using the profiles given in the current 4-D model.

Vehicle reentry problems, unfortunately, require data at much higher levels to predict the temperatures and densities encountered by a missile returning from space since some of the severest conditions could occur at these levels. Stratospheric studies, by definition, require data in the 20 to 50 km range and the proposed SST's make these more urgent than ever.

To meet these needs, means and variances of temperature, pressure, density, wind speed and wind direction from 25 to 50 km must be added to the 4-D models. Due to the scarcity of data above 30 km, it is recommended that the original grid spacing be used only up to 30 km, and that separate models, with less vertical and horizontal resolution, be created to contain statistics from 30 to 50 km. Section 7.2 will discuss this problem in more detail.

7.1 Generation of Wind Statistics

Wind statistics may be derived from a large set of data already on tape at ERT, which is derived from sounding data stored in the MIT general circulation data library. These data include the following for each of about 800 radiosonde stations: Σu, Σu^2, Σv, Σv^2, Σz, Σz^2, and N, for constant pressure surfaces from 1000 to 10 mb, where u is the zonal wind component, v is the meridional component, z is the height, and N is the number of observations for each quantity at each pressure level for each station. These quantities have been computed for monthly, seasonal, and annual values using five years of data (1958-1963).

The means ($\bar{u}$, etc.) and standard deviations (σ_u, etc.) of each parameter can be easily computed for each station using the above data. These statistics for each pressure surface can then be transferred to the NMC grid (Northern Hemisphere) and a 5° latitude grid (Southern Hemisphere) using the ANAL68 analysis programs on file at ERT, and other routines developed to derive the initial 4-D model.

The results of this data processing will be in the form of constant pressure maps giving the monthly means and standard deviations of u, v, and z. Since statistics u, v, σ_u, and σ_v for fixed kilometer levels will not be generated directly, values will have to be interpolated for heights between pressure levels using the approach followed in converting the other parameters (e.g., temperature) from pressure levels to height levels. The value of a parameter for a constant pressure surface could be used when the required height lies within, say, 100 m of the pressure surface at the particular grid point.

Undesirable features are present in any set of wind statistics for heights above about 16 km (100 mb surface) since wind statistics become less reliable above the 100 mb level because of the decreasing amount of data with increasing height. Furthermore, all wind data tend to be biased toward lower speeds for higher levels since a strong wind will often carry a balloon over the horizon, and thereby not allow the wind speed to be recorded. However, sufficient accuracy would be available to provide a good estimate of the winds.

The result of this processing would be monthly means and variances of the u and v wind components at fixed kilometer levels for the 3490 grid points in the 4-D grids. In any mission simulation, a chosen set of u and v components could be easily converted to wind speed and direction through standard trigonometric relationships, but it is felt that the use of the components provides a better initial set of statistics since averaging around the 360° circle of wind direction is very difficult. (The mathematical average of 355° and 5° is 180°, the physical average is 360°.)

Region wind statistics can then be found by averaging the wind statistics for the grid points providing a second data set corresponding to the region means and variances for the original parameters. Since the wind statistics would probably be used less frequently than, and often independently of, the initial 4-D models, it is planned that the wind statistics form a separate data set and that routines be developed which permit their joint use with the original data set. However, if it appears desirable, the initial data set and programs could be altered to include the winds directly.

7.2 Extension of the 4-D Model to 50 km

The 4-D model may be extended from 25 to about 33 km (10 mb) using radiosonde data on hand at ERT, but rocketsonde data must be used for greater heights. The following paragraphs will briefly describe the available data and discuss limitations and possible approaches to its use.

Tapes of rocketsonde data are currently stored at ERT for the years 1959 through 1971. These NOAA data include wind and temperature for heights from 25 to above 50 km. A separate tape contains grid map data for the 5, 2 and 0.4 mb pressure surfaces for January, April, July, and October of 1964-1966, where heights and temperatures are given for 5° latitude and longitude intervals. No wind data are included on this tape.

Tabulated data from rocketsondes can be found in Groves (1971) for wind, temperature, pressure, and density from 25 to 120 km. Monthly models are presented in a series of tables and figures. Another set of tables give the mean and standard deviation of differences between the models and selected stations. The tabulated data are listed for every 5 km from 25 km and for every 10° of latitude from 0 to 80° N or S. Longitudinal variations are not included, largely because of insufficient data.

Certain limitations are present in these data. Information extracted from the data will be less reliable than that from radiosondes and much variation will be smoothed out because of the relative scarcity of data from meteorological rockets. Most soundings occur within the Western Hemisphere (70 to 160°W) and north of the equator. For the temperature models, the data from the Northern and Southern Hemispheres are combined using a six month change of date. Furthermore, realistic models at high latitudes in winter are difficult because longitudinal variations are comparable in size with latitudinal ones, largely as a consequence of the Aleutian high pressure area (Groves, 1971).

Some other, less important effects complicate the interpretation of the data, one of which is the diurnal variation in temperature, pressure, and density. Too few observations are available to make any quantitative estimate, but the observations are biased towards the local noon value (most rockets are launched within a few hours of 1200 LST). Nevertheless, the diurnal variation of these parameters appears to be only of the order of 5%, within the limits of error of the sensors (see Groves, 1971). Wind measurements contain tidal (12 and 24 hour) and quasi-biennial variations which generally have a magnitude on the order of 10 m sec^{-1} and 5 m sec^{-1}, respectively. However, these components may reach 20 m sec^{-1} at some height or latitude (Groves, 1971). Fortunately, the seasonal component need not be extracted since monthly means and standard deviations will be used for this study.

Radiosonde and rocketsonde data may be combined for heights between 25 and about 33 km (10 mb). Unfortunately, they do not generally agree; for example, temperatures from the two methods are often different by 5°C or more. Further work should, therefore, be devoted to finding a means of reconciling the two types of data.

Perhaps the best approach to obtaining the required statistics would be to utilize data from Groves, tapes at ERT (NOAA data), and radiosonde tapes. As a first step, information would be extracted from the Groves data and checked by using a limited sample from the NOAA tapes. This investigation would ask, for example, would interpolating between 5 km levels be sufficient for generating temperature statistics for intermediate levels? If good statistics can be obtained from the data of Groves without the addition of "unprocessed" data from the NOAA tapes, a large amount of time, effort, and money will be saved.

Even if the Groves data appears acceptable for levels above 30 km, it would be desirable to use the larger data set available up to 30 km. The original NMC grid data tapes used to derive temperature and heights to 25 km actually contained values up to 33 km. These grids were based on analyzed radiosonde data and naturally are consistent with the grids used at the lower levels. It is recommended that these values are used to derive means and variances of temperature and height up to 30 km for the NMC grid and that every effort be made to supply wind data.

It was impossible to find Southern Hemisphere data above 23 km for the initial data set. Additional data is now available in sounding format, and and combined with Groves' analyses, might permit the vertical extension of profiles in this area. Unfortunately, most data represent conditions above Australia and Antarctica so any hemispheric model must reflect this observational bias.

Above 30 km, it may be necessary to generate statistics only on a latitudinal basis as was done by Groves (1971). This would probably provide as much resolution as can be derived from the available data, although every effort will be made to derive statistics corresponding to 4-D regions. The same problem applies to the Southern Hemisphere at all levels above 25 km since soundings (either radiosonde or rocketsonde) are very scarce throughout the entire hemisphere. However, the addition of even regional statistics from 25 to 50 km would greatly extend the value of the 4-D models.

8. SUMMARY AND CONCLUSIONS

The study presented in the previous sections of this report has investigated a number of problems associated with the development of a cloud type statistics data bank. Principally, these problems are in the areas of regional homogeneity and regional difference, temporal and spatial conditionality of cloud type probabilities, and the incorporation of cloud type statistics in a more sophisticated scheme for computer simulation. In summary, the significant findings of this study may be stated as follows.

8.1 Regional Homogeneity and Difference

It was noted that in the development of the cloud type statistics (Chang and Willand, 1972), the region boundaries defined by Sherr et al (1968) for the original cloud cover statistics were accepted as directly applicable to cloud types. The cases selected for this study did show that on the whole the regional definitions by Sherr et al are acceptable. These cases, while limited in number, did include regions with cloud types representative of coastal regions, mid-continental regions in the path of synoptic storms, and desert regions. Between stations within regions, differences in statistics, especially for mid-continental regions, were indeed small, often less than a few percent. This is particularly the case if seasonal statistics are compared. On the other hand, statistics between stations from two distinct regions are sufficiently different to justify their categorization as being from two separate regimes.

Despite these favorable findings, a number of exceptions were discussed. Most significant of these, perhaps, is the marked difference in cloud type statistics between those compiled for the U. S. southwestern deserts and the Sahara region, both being originally defined as belonging to cloud Region 2. The difference lies in the much more frequent occurrence of convective clouds in the U. S. deserts suggesting the penetration of moisture-laden air from the Gulf of Mexico, or even from the Pacific. While seasonal statistics of cloud cover between the two areas in Region 2 are quite similar, the differences in cloud type suggests the definition of a new cloud regime for this part of the United States. For this reason, the cloud type statistics from Las Vegas were compiled in the CLOUDT format (see Section 1.2.1) and listed in Appendix A as Region 30.

A second point of interest developed from the current study, is the care with which one must treat cloud statistics for stations or areas at the edges of the cloud regions. The case in point was China Lake in California. This station lies to the lee of the Sierra Nevada mountains but because of some artificial requirements in the definitions of regional boundaries, it was included in Region 18, a typical coastal cloud regime. Examination shows that the cloud amount and cloud type statistics for China Lake are very similar to those for Las Vegas, as one would expect from climatic and geomorphological consideration and the region boundary was changed to parallel the mountain range. It must therefore be emphasized again that considerable care must be exercised in applying regional statistics to areas at the edges of cloud regions. One possible objective approach to alleviate this problem is to obtain the average statistics between the contiguous regions, and use these as being more representative of the areas near the corresponding region boundaries.

8.2 Conditionality

Three types of conditionality were investigated: temporal conditionality, spatial conditionality, and conditionality based on the given occurrence of a major cloud type. A number of interesting features in these statistics were found and discussed in Section 4.5. The most important of these may be summarized as follows.

8.2.1 Temporal Conditionality

Most cloud types show significant persistence in a time period of three hours. This suggests that in viewing missions with orbital periods of three hours or less in which the field of view of the sensors have edge overlaps, it might be necessary to incorporate the conditionality in the simulation scheme. Apart from stratus, however, most clouds lose significant temporal conditionality beyond 12 hours, and certainly after 36 hours. Convective clouds, as expected, exhibit a 24-hour diurnal cycle which should be considered in simulation studies. Unexpectedly, cirrus also exhibit a 24-hour cycle. It is not clear what the factors are which result in this cyclic reappearance of cirrus. At present, it is the belief that this cycle is spurious.

8.2.2 Spatial Conditionality

There exists a well marked spatial conditionality in cloud type statistics up to distances of 100 n.mi. in any direction. As expected, significant spatial conditionality extends beyond 225 n.mi. for stratus, and for synoptic storm types of clouds. There is a greater conditionality in the north-south direction than in the west-east direction for clouds associated with synoptic systems.

8.2.3 Conditionality Based on Cloud Type

This kind of conditionality was found, not unexpectedly, to reflect the dynamical processes which formed the clouds. Steady upward rise of air associated with a warm front generally gives rise to stratiform clouds. Not surprisingly, therefore, is the result that the appearance of one type of stratiform clouds, stratus, altostratus, cirrostratus, is highly correlated to the appearance of another form of stratus. During summer months, the appearance of cirrus is often associated with the appearance of cumulonimbus, suggesting that the cirrus is the result of the spreading of the cumulonimbus at the tropopause.

8.3 Evaluation of Mission Simulation

The hypothetical mission simulation performed during this study has clearly demonstrated the feasibility of combining the cloud statistics and the 4-D atmospheric model into a complete simulation package. Selection of temperature and moisture profiles unique to specified locations and passes proved feasible using just the information contained in the 4-D model. The insertion of clouds into these profiles, and their appropriate modification was also demonstrated, with the resulting profiles well representing the expected atmospheric conditions. Analysis of the integrated liquid water and water vapor amounts showed that the simulation generally reproduced the observed statistics of cloud type and precipitable water amounts and showed that the expected success of missions dependent upon atmospheric moisture could be determined.

The study also demonstrated that the Monte Carlo technique worked as well for the selection of cloud types, and the number of cloud layers, as it did for the choice of cloud cover amount. The use and reliability of the

Markov scaling procedure was also shown, and conditions defined where this scaling procedure was inapplicable. Lastly, a procedure was developed which, giving a cloud cover category, selected a cloud cover amount in tenths.

Despite the overall success of this simulation, certain refinements are recommended. First more research is needed to develop a technique which permits realistic variation in the shape of the temperature profile. The statistics in the 4-D model provide no information on the correlation of temperature changes in various levels. Independent variation of each level produces unrealistic profiles while constant shifts for all levels eliminates inversions and extremely unstable conditions. This problem requires additional study.

The amount of moisture present in cloud layers also needs further investigation since specification of saturation seems to cause unrealistically high values of integrated water vapor. Furthermore, the spatial and temporal conditionality for cloud types and number of cloud layers should be generalized to reflect global conditions, and incorporated into the mission simulation scheme since cloud types show as much conditionality as cloud cover. However, it is felt that the simulation used in the study demonstrates the basic approach to combining the 4-D models and the cloud statistics and provides realistic information for mission planning.

8.4 The Cloud Type Parameters

The cloud models proposed in this study provide statistics on cloud heights, liquid water content, droplet size distribution and density. These statistics indicate the representative and maximum values expected and the general variability within each cloud type. They are considered an important addition to the cloud statistics data bank since no simulation requiring knowledge of the clouds present can be performed without them, and many satellite sensors are affected more by the vertical distribution of liquid water or scattering by large drops than by the simple presence of clouds.

8.5 The Modification of the 4-D Model

Investigation of the possible uses for the 4-D model have led to the recommendation of its extension to 50 km and the addition of winds at all levels. The approach to these improvements has already been presented, and it is here recommended that this approach be implemented.

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APPENDIX A

MONTH 1 REGION 10

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													65
2	0	9	0	0	0	4	1	3	0	11	3	0	
3	0	8	0	0	1	2	1	3	0	11	2	0	
4	0	28	0	0	3	9	0	6	0	42	2	0	
5	0	59	6	0	8	10	2	7	0	76	7	0	
LST# 4													63
2	0	18	0	0	1	1	2	4	0	26	0	0	
3	0	7	0	0	1	0	0	0	0	8	0	0	
4	0	35	0	0	6	7	1	3	0	40	6	0	
5	0	59	5	0	7	17	2	5	0	78	7	1	
LST# 7													36
2	0	30	0	0	6	7	0	2	0	45	0	0	
3	0	12	1	0	0	4	1	2	0	18	1	0	
4	0	33	0	0	8	5	1	7	0	40	7	0	
5	0	60	3	0	6	12	1	4	0	64	12	0	
LST#10													41
2	1	30	0	0	2	6	5	3	0	37	5	0	
3	0	8	0	0	0	2	1	1	0	5	2	1	
4	0	44	3	0	5	11	2	11	0	41	16	1	
5	0	58	7	0	11	12	2	7	0	51	20	2	
LST#13													47
2	2	17	0	0	2	5	2	3	0	25	3	0	
3	0	14	0	0	0	1	0	1	0	14	1	0	
4	1	38	2	0	3	14	3	13	0	36	18	0	
5	0	63	7	0	14	14	0	13	1	51	24	4	
LST#16													43
2	4	16	0	0	2	4	4	2	0	22	5	0	
3	0	14	0	0	2	3	1	4	0	14	3	1	
4	5	43	1	0	3	11	1	16	0	32	24	0	
5	1	62	8	0	13	13	0	9	0	56	25	2	
LST#19													35
2	1	25	0	0	3	10	5	5	0	43	3	0	
3	1	10	0	0	2	1	1	3	0	16	1	0	
4	0	38	1	0	0	5	0	7	0	37	7	0	
5	2	59	6	0	13	13	1	9	0	49	28	2	
LST#22													57
2	0	16	0	0	5	4	1	7	0	31	1	0	
3	0	9	0	0	3	2	1	1	0	14	1	0	
4	0	28	0	0	2	7	1	5	0	37	3	0	
5	0	51	6	0	12	12	0	6	0	63	12	0	

MONTH 2 REGION 10

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													76
2	0	12	0	0	3	0	0	3	0	16	1	0	
3	0	6	0	0	1	3	1	0	0	9	1	0	
4	0	26	0	0	3	1	0	6	0	30	3	0	
5	0	44	9	0	16	10	0	13	1	64	13	1	
LST# 4													70
2	0	14	1	0	2	2	0	2	0	21	0	0	
3	0	7	1	0	3	1	0	3	0	11	2	0	
4	0	17	1	0	1	3	0	4	0	22	2	0	
5	0	51	13	0	12	7	0	13	1	72	11	1	
LST# 7													47
2	0	20	1	0	8	2	0	8	0	37	1	0	
3	0	9	1	0	1	3	1	2	0	9	4	0	
4	0	29	1	0	3	4	0	5	0	32	5	0	
5	0	48	13	0	9	8	0	10	0	56	13	2	
LST#10													67
2	1	12	0	0	1	2	1	6	0	23	1	0	
3	0	9	0	0	1	2	2	3	0	11	3	0	
4	0	36	2	0	6	6	2	10	0	23	13	4	
5	0	48	14	0	16	11	0	13	0	39	30	1	
LST#13													52
2	4	21	0	0	1	2	3	8	0	31	4	0	
3	1	10	0	0	0	1	3	2	0	9	4	0	
4	2	31	3	0	5	9	7	18	0	33	15	4	
5	0	43	15	0	11	11	0	11	0	26	25	5	
LST#16													53
2	3	17	0	0	1	1	0	8	0	22	6	0	
3	3	4	0	0	0	4	2	2	0	5	5	0	
4	2	38	1	0	6	7	4	16	0	24	25	0	
5	0	47	11	0	16	14	1	21	2	37	33	3	
LST#19													45
2	0	15	0	0	1	1	6	11	0	32	1	0	
3	1	14	0	0	5	2	1	6	0	13	8	0	
4	0	25	1	0	4	2	1	11	0	25	9	1	
5	0	51	10	0	17	17	2	14	0	33	36	2	
LST#22													67
2	0	14	0	0	3	1	1	8	0	25	1	0	
3	0	7	0	0	1	3	0	1	0	8	2	0	
4	0	28	0	0	2	3	0	9	0	28	7	0	
5	0	43	13	0	17	8	0	11	0	59	15	1	

MONTH 3 REGION 10

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													97
2	0	4	0	0	0	2	4	5	0	15	0	0	
3	0	4	0	0	2	0	0	3	0	9	0	0	
4	0	24	2	0	3	3	0	4	0	30	3	0	
5	0	45	10	0	14	8	0	16	1	56	18	0	
LST# 4													90
2	1	9	0	0	4	1	0	3	0	18	0	0	
3	0	3	0	0	0	1	0	2	0	6	0	0	
4	0	19	0	0	3	2	0	4	0	26	1	0	
5	0	50	13	0	16	11	0	13	2	63	21	0	
LST# 7													38
2	1	18	0	0	5	5	5	10	0	36	4	0	
3	0	12	1	0	3	4	7	5	0	13	8	1	
4	0	25	2	0	10	7	2	11	0	20	13	1	
5	0	43	18	0	16	11	0	16	0	44	26	2	
LST#10													34
2	2	19	0	0	0	2	6	5	0	24	5	0	
3	0	7	0	0	1	1	0	3	0	8	2	0	
4	0	20	2	0	4	17	7	14	0	30	18	1	
5	0	47	23	0	20	19	2	25	0	56	34	4	
LST#13													51
2	2	14	0	0	1	1	5	4	0	23	2	0	
3	3	7	0	0	0	3	2	5	0	9	4	1	
4	0	21	2	0	3	8	6	20	0	26	17	2	
5	2	55	16	0	15	17	1	29	1	63	36	7	
LST#16													41
2	4	10	0	0	3	1	5	9	0	22	5	0	
3	3	7	1	0	1	5	5	10	0	13	6	2	
4	3	22	2	0	7	5	4	19	0	23	12	5	
5	2	60	13	0	16	22	1	26	2	51	37	5	
LST#19													40
2	0	12	1	0	2	5	7	10	0	27	5	0	
3	1	7	0	0	1	5	3	5	0	12	5	0	
4	1	19	1	0	6	6	5	10	0	27	12	1	
5	0	51	15	0	20	10	2	27	2	43	43	2	
LST#22													66
2	0	6	0	0	1	3	2	0	0	10	1	0	
3	0	2	0	0	3	0	1	3	0	7	1	0	
4	0	10	0	0	6	6	1	12	0	27	6	0	
5	0	40	16	0	9	9	1	15	2	59	16	1	

MONTH 4 REGION 10

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													117
2	0	4	0	0	0	4	5	2	0	15	0	0	
3	0	0	1	0	1	2	5	2	0	11	0	0	
4	0	6	0	0	7	3	0	16	0	24	4	0	
5	0	35	11	0	6	11	0	24	3	58	17	0	
LST# 4													105
2	1	4	2	0	1	3	4	5	0	20	0	0	
3	0	1	0	0	3	0	3	2	0	7	1	0	
4	1	8	0	0	3	4	1	12	0	19	5	0	
5	0	35	16	0	14	19	0	22	3	63	17		
LST# 7													32
2	1	1	0	0	4	2	6	11	0	21	2	0	
3	0	7	0	0	3	2	3	4	0	6	5	1	
4	1	18	3	0	6	18	7	19	0	29	18	1	
5	0	45	15	1	16	28	0	24	2	45	32	7	
LST#10													59
2	4	7	1	0	0	2	7	10	0	25	3	0	
3	2	4	0	0	1	0	0	2	0	3	3	0	
4	3	13	1	0	4	7	8	17	0	27	13	0	
5	1	50	20	0	18	23	2	30	2	49	41	5	
LST#13													54
2	11	9	0	0	2	6	6	11	0	31	9	0	
3	2	3	0	0	0	1	0	3	0	3	3	0	
4	5	19	3	0	6	11	14	19	0	28	17	3	
5	2	47	19	0	19	14	0	32	0	52	39	1	
LST#16													50
2	9	8	0	0	0	3	11	13	0	28	9	0	
3	4	2	1	0	1	2	5	6	0	6	6	1	
4	4	13	2	0	6	11	12	31	0	32	17	5	
5	3	52	15	0	17	21	2	22	2	44	38	7	
LST#19													56
2	2	5	0	0	2	3	13	11	0	20	4	0	
3	2	1	0	0	2	6	4	10	0	6	4	3	
4	5	8	1	0	16	17	5	32	0	25	22	3	
5	0	45	21	0	21	16	2	26	2	41	37	6	
LST#22													114
2	0	1	0	0	0	3	0	13	0	29	0	0	
3	0	2	0	0	1	0	3	6	0	4	2	0	
4	1	6	1	0	6	5	1	9	0	13	0	0	
5	0	30	12	0	13	11	0	20	1	58	13	3	

MONTH [illegible] REGION 10

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													01
2	0	3	1	0	5	3	0	10	0	22	0	0	
3	0	0	0	0	1	2	1	0	0	12	2	0	
4	0	5	1	0	3	6	3	17	0	19	0	0	
5	0	32	27	0	16	12	0	12	1	57	20	1	
LST= 4													02
2	0	2	0	0	5	0	3	12	0	20	1	0	
3	0	1	0	0	2	2	1	3	0	9	3	0	
4	0	12	4	0	6	5	1	10	0	24	7	0	
5	0	31	23	0	9	15	0	16	0	57	17	1	
LST= 7													02
2	0	7	0	0	2	3	13	7	0	26	3	0	
3	0	1	0	0	0	1	2	7	0	9	1	0	
4	1	16	2	0	5	16	4	19	0	22	16	3	
5	0	47	19	0	10	20	3	33	0	43	30	7	
LST=10													02
2	4	4	0	0	2	2	0	13	0	25	4	0	
3	2	7	0	0	0	5	4	6	0	7	5	2	
4	5	0	3	0	3	12	7	19	0	26	11	3	
5	2	53	14	0	24	20	4	35	1	40	49	5	
LST=13													01
2	12	5	1	0	1	4	0	23	0	32	11	0	
3	5	2	0	0	1	1	5	5	0	5	7	0	
4	10	8	0	0	2	15	4	28	0	20	22	1	
5	4	49	10	1	21	27	2	35	1	29	48	8	
LST=16													34
2	12	3	0	0	1	6	7	10	0	28	0	1	
3	4	5	2	0	1	2	2	4	0	7	6	2	
4	0	15	0	0	5	14	4	33	0	24	19	4	
5	5	46	12	0	21	17	2	29	1	35	37	8	
LST=19													38
2	7	5	2	0	0	6	7	10	0	30	6	1	
3	1	1	0	0	0	1	1	7	0	9	1	0	
4	5	16	1	0	9	7	3	24	0	20	18	3	
5	3	43	20	0	25	26	0	31	0	42	41	9	
LST=22													06
2	1	4	0	0	3	3	4	10	0	31	1	0	
3	0	1	1	0	1	2	2	5	0	12	0	0	
4	0	11	1	0	2	7	1	14	0	16	10	0	
5	0	40	20	1	22	19	0	14	1	55	28	2	

MONTH 6 REGION 10

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													52
2	0	9	2	0	1	1	2	12	0	27	0	0	
3	0	3	2	0	2	1	0	3	0	5	3	0	
4	1	11	5	0	3	3	1	10	0	20	7	0	
5	0	49	37	0	16	12	1	22	1	57	36	3	
LST= 4													53
2	0	5	2	0	0	2	1	6	0	18	1	0	
3	0	3	0	0	1	1	0	3	0	4	0	0	
4	0	11	5	0	5	6	1	11	0	17	11	3	
5	0	60	40	1	14	0	2	20	3	71	31	5	
LST= 7													11
2	0	0	2	0	3	3	4	9	0	25	1	0	
3	0	5	1	0	0	4	5	1	0	3	5	1	
4	3	37	2	0	6	13	5	20	0	25	18	0	
5	2	64	39	0	8	21	1	18	4	60	42	6	
LST=10													45
2	3	0	1	0	1	3	5	2	0	13	5	0	
3	3	4	2	0	2	2	3	6	0	8	4	2	
4	0	33	3	0	5	17	9	25	0	20	31	5	
5	5	67	29	0	11	25	2	24	3	44	54	11	
LST=13													15
2	10	9	1	0	1	2	5	6	0	16	9	0	
3	11	8	0	0	2	2	2	8	0	8	11	1	
4	16	39	0	0	4	13	4	30	0	23	32	4	
5	8	78	22	0	16	20	1	24	4	25	44	20	
LST=16													17
2	20	7	1	1	1	3	0	14	0	10	21	1	
3	0	7	1	0	2	2	0	6	0	4	6	2	
4	24	31	3	0	8	16	6	25	0	14	30	13	
5	7	68	26	0	16	13	0	27	4	37	48	9	
LST=19													16
2	10	10	0	0	1	4	5	11	0	18	10	1	
3	9	6	2	0	1	0	7	4	[illegible]	9	4	[illegible]	
4	8	27	5	0	7	14	2	25	0	16	27	6	
5	1	67	35	0	19	12	2	25	4	43	46	10	
LST=22													35
2	1	13	0	0	5	4	5	15	0	32	4	1	
3	0	3	1	0	1	2	1	2	0	8	1	0	
4	0	17	6	0	7	6	3	11	0	18	16	0	
5	0	50	30	0	15	9	1	18	2	54	34	1	

MONTH 7 REGION 10

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													53
2	1	7	2	0	2	6	2	1	0	19	1	0	
3	0	6	1	0	2	0	1	3	0	9	6	0	
4	0	22	6	1	3	9	0	7	0	30	9	0	
5	0	78	23	0	7	18	0	5	2	50	34	3	
LST= 4													02
2	0	9	2	1	0	7	0	3	0	10	2	0	
3	0	0	0	0	0	3	0	3	0	0	3	0	
4	0	20	5	0	0	15	1	7	0	24	12	0	
5	2	67	24	0	9	13	0	6	2	72	31	3	
LST= 7													3
2	2	4	1	0	1	0	0	0	0	11	5	1	
3	1	5	0	0	0	9	3	2	0	7	5	1	
4	6	54	9	0	4	33	7	15	0	16	38	12	
5	2	103	40	0	10	24	0	16	2	57	50	14	
LST=10													4
2	7	7	0	0	0	6	1	3	0	7	7	1	
3	0	8	1	1	1	9	0	4	0	0	10	4	
4	13	55	11	0	6	39	15	20	0	13	47	17	
5	5	117	32	1	20	19	0	8	1	29	59	18	
LST=13													3
2	13	0	0	0	2	1	1	3	0	14	0	0	
3	12	9	0	1	1	7	3	6	0	7	10	4	
4	20	50	5	1	3	32	17	20	0	0	48	20	
5	17	115	30	1	16	25	3	15	3	21	52	43	
LST=16													7
2	12	10	0	1	3	2	6	3	0	14	10	1	
3	10	4	1	2	2	4	0	0	0	5	9	6	
4	39	37	2	2	6	39	15	30	0	4	47	75	
5	12	100	23	0	10	25	2	17	4	27	52	24	
LST=19													18
2	11	7	0	0	0	5	3	3	0	9	10	0	
3	11	11	0	1	3	17	6	0	0	5	12	7	
4	33	50	1	0	7	42	11	30	0	11	33	35	
5	0	92	21	2	10	24	2	12	1	26	50	14	
LST=22													32
2	1	10	0	0	1	11	2	6	0	27	6	0	
3	0	0	1	0	1	3	1	5	0	7	6	0	
4	2	30	2	0	6	20	0	19	0	19	33	2	
5	2	03	10	0	0	11	0	3	2	40	30	7	

MONTH 8 REGION 10

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													74
2	4	11	4	0	2	8	5	11	0	41	2	0	
3	0	3	1	0	2	0	0	2	0	4	2	0	
4	3	15	4	1	6	15	4	8	0	10	16	2	
5	1	45	9	0	9	21	0	6	1	34	29	3	
LST= 4													74
2	1	10	5	0	1	7	3	7	0	32	1	0	
3	0	7	2	0	1	4	1	2	0	13	2	0	
4	2	20	7	0	5	14	2	7	0	24	15	1	
5	1	51	11	1	10	13	1	4	1	40	25	1	
LST= 7													13
2	9	14	0	0	1	8	4	10	0	19	12	1	
3	2	7	2	0	1	10	4	5	0	9	11	0	
4	7	42	3	1	5	39	13	17	0	10	34	13	
5	3	77	16	1	12	29	2	16	3	20	45	12	
LST=10													19
2	12	12	0	0	1	6	4	9	0	17	12	1	
3	4	14	0	0	2	4	1	2	0	7	7	2	
4	19	62	3	0	11	37	14	25	0	23	50	15	
5	7	55	18	1	9	30	2	21	1	17	30	23	
LST=13													13
2	20	9	0	0	2	3	11	3	0	20	18	6	
3	16	9	0	0	1	7	7	7	0	4	17	3	
4	47	38	1	1	7	37	10	36	0	11	41	30	
5	13	55	16	1	12	24	1	11	1	0	39	16	
LST=16													16
2	43	13	0	1	3	6	10	11	0	27	30	0	
3	9	4	0	2	1	3	4	7	0	1	10	3	
4	50	24	4	2	5	43	10	35	0	9	39	30	
5	13	47	0	1	10	21	2	14	1	7	34	15	
LST=19													19
2	23	15	0	0	0	10	12	9	0	26	20	1	
3	16	7	0	1	1	9	10	11	0	5	20	3	
4	32	27	1	2	9	32	16	36	0	9	41	21	
5	0	53	10	0	10	15	1	17	2	9	36	16	
LST=22													59
2	9	20	3	3	4	9	9	13	[illegible]	[illegible]	8	2	
3	3	0	0	0	2	8	2	5	0	6	6	2	
4	2	21	3	0	4	12	9	20	[illegible]	[illegible]	23	3	
5	1	47	2	0	11	15	1	[illegible]	1	16	29	3	

MONTH 9 REGION 10

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													82
2	2	10	3	0	0	13	3	8	0	31	4	0	
3	1	5	1	0	1	4	3	3	0	14	2	0	
4	3	12	2	0	7	17	0	25	0	24	18	2	
5	3	31	10	0	13	16	2	7	1	22	26	3	
LST= 4													76
2	3	6	1	0	3	16	3	10	0	36	1	0	
3	2	6	1	0	0	5	1	4	0	13	3	0	
4	6	18	1	0	7	10	0	12	0	25	10	1	
5	3	27	12	0	9	19	1	16	2	33	22	4	
LST= 7													33
2	5	9	0	0	3	13	3	8	0	21	10	0	
3	5	13	0	0	1	11	2	6	0	3	18	1	
4	6	28	4	0	13	37	10	22	0	10	43	9	
5	4	30	13	0	17	30	1	15	3	21	34	10	
LST=10													34
2	7	10	0	0	1	12	6	6	0	20	5	2	
3	6	8	0	0	0	8	6	5	0	9	12	0	
4	11	19	2	0	6	34	6	21	0	18	26	10	
5	5	43	12	0	13	39	2	26	3	19	44	12	
LST=13													26
2	21	12	0	0	0	13	7	13	0	34	13	2	
3	12	5	0	0	2	4	5	10	0	5	15	1	
4	15	22	0	0	7	35	14	17	0	13	27	15	
5	10	44	10	0	21	28	0	18	3	14	33	18	
LST=16													28
2	26	12	0	0	0	10	5	12	0	31	14	2	
3	13	6	0	0	1	6	4	14	0	6	13	4	
4	23	20	1	0	6	28	11	29	0	11	31	15	
5	12	38	8	0	19	19	1	20	2	16	27	16	
LST=19													43
2	11	9	0	0	2	12	3	11	0	72	13	0	
3	7	3	0	0	4	6	2	8	0	3	6	5	
4	11	18	0	1	6	33	12	32	0	29	25	11	
5	3	37	11	1	10	31	2	15	2	16	30	11	
LST=22													76
2	7	8	0	0	3	12	3	16	0	35	7	0	
3	1	6	0	0	1	9	2	6	0	9	8	0	
4	2	13	0	0	3	17	3	18	0	16	20	0	
5	1	32	7	0	12	26	2	8	3	23	31	2	

MONTH 10 REGION 10

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													136
2	2	10	1	0	3	6	5	9	0	30	3	0	
3	1	5	0	0	1	1	3	5	0	16	0	0	
4	1	10	1	0	6	5	0	7	0	20	5	0	
5	0	20	12	0	3	14	0	12	2	22	19	1	
LST= 4													123
2	4	12	2	0	0	3	5	4	0	30	0	0	
3	0	8	0	0	2	7	1	4	0	20	1	0	
4	1	15	1	0	3	4	1	9	0	23	4	1	
5	0	18	12	1	6	15	0	7	2	28	15	1	
LST= 7													78
2	6	12	0	0	4	13	10	5	0	35	6	1	
3	2	10	0	0	2	8	3	3	0	19	3	1	
4	0	24	3	1	6	25	4	13	0	27	18	4	
5	2	23	6	0	9	17	0	8	1	14	20	4	
LST=10													93
2	7	15	2	0	0	13	8	8	0	33	10	0	
3	1	7	0	0	1	6	3	2	0	11	3	1	
4	1	21	1	1	9	22	8	17	0	20	21	6	
5	1	26	7	0	14	19	2	9	1	14	23	6	
LST=13													75
2	19	13	0	0	2	6	11	6	0	43	8	0	
3	8	9	0	0	2	4	6	3	0	10	11	0	
4	3	21	0	0	6	25	4	25	0	23	23	5	
5	3	28	4	1	9	17	0	10	0	12	21	6	
LST=16													77
2	17	13	0	0	2	8	10	17	0	32	18	1	
3	12	7	0	0	0	5	6	11	0	13	11	2	
4	6	14	1	0	11	10	4	16	0	10	14	5	
5	2	29	2	0	9	22	0	14	1	14	28	3	
LST=19													92
2	6	8	0	0	4	6	6	14	0	34	5	0	
3	4	7	0	0	2	5	3	5	0	12	7	3	
4	3	26	0	0	11	23	3	19	0	18	27	4	
5	3	29	6	0	6	19	0	7	3	14	21	7	
LST=22													135
2	3	8	0	0	4	11	5	8	0	35	2	0	
3	1	7	0	0	2	0	1	3	0	12	1	0	
4	1	11	0	0	4	6	1	8	0	18	5	1	
5	2	19	7	0	9	16	2	6	3	23	18	3	

MONTH 11 REGION 10

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													110
2	1	16	0	0	5	6	4	5	0	37	8	1	
3	0	5	0	0	0	2	0	2	0	7	1	0	
4	0	21	0	0	3	7	1	3	0	29	3	0	
5	1	41	4	0	6	12	3	2	2	37	14	1	
LST= 4													134
2	0	15	0	0	2	7	2	4	0	26	2	0	
3	0	6	0	0	[illegible]	8	1	2	0	13	2	0	
4	1	20	0	0	[illegible]	10	1	3	0	23	8	1	
5	0	37	7	0	7	9	0	1	3	46	10	2	
LST= 7													60
2	1	22	1	0	4	9	3	2	0	34	4	3	
3	0	17	0	0	0	6	2	2	0	10	4	1	
4	0	39	1	0	6	17	3	6	1	33	18	2	
5	0	35	4	0	6	12	1	9	1	31	18	1	
LST=10													48
2	0	20	0	0	1	7	2	8	0	34	2	0	
3	1	7	0	0	6	3	3	3	0	7	5	3	
4	2	38	0	0	5	29	6	12	2	40	23	3	
5	0	25	4	0	11	16	4	5	2	21	23	0	
LST=13													53
2	7	18	0	0	2	4	4	11	0	26	9	2	
3	4	9	0	0	0	6	2	2	0	13	4	0	
4	4	41	1	0	4	22	6	14	0	41	23	3	
5	3	27	2	0	6	21	2	7	2	16	24	2	
LST=16													53
2	13	26	0	0	0	9	3	19	0	51	8	1	
3	2	6	0	0	1	8	1	4	0	6	5	0	
4	6	36	0	0	6	29	0	14	0	29	22	3	
5	1	37	5	0	5	16	2	12	2	16	28	0	
LST=19													74
2	6	18	0	0	2	6	7	9	0	44	2	0	
3	1	10	0	0	4	6	1	3	0	17	4	0	
4	2	22	0	0	3	19	2	16	0	36	15	1	
5	1	33	5	0	5	11	0	2	1	23	16	1	
LST=22													125
2	0	14	0	0	2	6	2	6	0	27	0	1	
3	3	4	0	0	1	7	0	3	0	16	4	0	
4	0	25	0	1	2	11	0	4	0	29	7	3	
5	0	32	5	0	4	10	0	5	1	27	15	0	

MONTH 12 REGION 10

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													83
2	0	12	1	0	0	2	0	4	0	17	1	0	
3	0	8	0	0	1	4	0	4	0	13	2	0	
4	0	36	3	0	1	6	1	10	0	42	6	1	
5	0	61	8	0	5	10	0	7	1	57	16	1	
LST= 4													85
2	0	16	0	0	0	4	1	1	0	22	0	0	
3	0	7	0	0	0	3	0	4	0	11	0	0	
4	0	36	0	0	2	6	0	2	0	40	3	0	
5	0	56	10	0	4	11	0	7	1	65	12	0	
LST= 7													39
2	0	25	0	0	5	7	3	6	0	44	1	0	
3	0	10	0	0	0	4	0	1	0	7	4	0	
4	0	49	2	0	3	9	0	4	0	65	11	0	
5	0	64	11	0	1	9	0	4	1	60	12	2	
LST=10													41
2	0	30	0	0	2	10	1	6	0	39	5	0	
3	0	10	0	0	1	3	0	4	0	9	1	1	
4	0	41	0	0	3	17	4	14	0	37	18	2	
5	0	61	11	0	4	16	0	7	2	34	25	5	
LST=13													65
2	2	22	0	0	1	8	7	9	0	39	5	3	
3	1	9	0	0	2	4	1	6	0	9	7	3	
4	1	39	0	0	2	11	3	13	0	30	14	1	
5	1	60	9	0	7	14	2	10	0	30	28	3	
LST=16													35
2	3	26	0	0	0	12	4	11	0	30	9	0	
3	0	12	0	0	1	2	3	0	0	12	3	0	
4	3	53	2	0	1	19	0	12	0	37	27	2	
5	1	63	5	0	7	13	0	10	1	32	34	0	
LST=19													55
2	0	25	0	0	1	9	1	12	0	37	5	0	
3	1	15	1	0	1	3	1	1	0	9	7	0	
4	0	46	1	0	1	14	2	5	0	44	11	1	
5	1	51	8	0	3	12	1	6	2	36	24	0	
LST=22													60
2	2	22	2	0	4	3	0	5	0	32	3	0	
3	0	14	0	0	0	3	0	4	0	11	5	0	
4	1	42	3	0	4	5	1	3	0	30	9	1	
5	0	51	5	0	5	11	0	6	1	56	10	1	

MONTH 1 REGION 15

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													127
2	0	2	0	0	10	3	1	0	0	20	2	0	
3	0	5	1	0	6	1	1	2	0	14	1	0	
4	0	10	1	0	11	2	3	7	0	19	6	0	
5	0	35	14	0	21	4	0	3	0	57	10	0	
LST= 4													117
2	0	11	0	0	16	1	0	9	0	33	2	0	
3	0	2	1	0	9	2	0	5	0	17	1	0	
4	0	4	5	0	9	3	1	7	0	27	1	0	
5	0	36	10	0	24	3	0	3	1	63	7	0	
LST= 7													102
2	0	18	1	0	15	5	1	12	0	42	1	0	
3	0	3	1	0	5	2	1	4	0	14	1	0	
4	0	14	3	0	10	7	0	8	0	32	5	0	
5	0	34	15	0	27	2	1	2	0	60	9	1	
LST=10													80
2	0	11	1	0	26	5	2	11	0	52	1	0	
3	0	1	0	0	4	3	1	3	0	6	3	0	
4	0	25	4	0	20	6	1	15	0	44	12	1	
5	0	37	14	0	17	3	0	8	0	52	12	1	
LST=13													67
2	0	5	2	0	20	6	2	16	0	47	2	0	
3	0	12	0	0	12	1	1	5	0	23	4	1	
4	0	28	6	0	26	8	2	8	0	42	13	2	
5	0	31	12	0	23	3	0	10	2	57	12	3	
LST=16													85
2	0	9	1	0	23	3	1	17	0	59	2	0	
3	0	8	2	0	6	4	1	3	0	9	6	1	
4	0	19	3	0	18	7	2	8	0	32	11	1	
5	0	30	11	0	25	3	0	4	2	51	12	0	
LST=19													115
2	0	7	0	0	13	1	1	10	0	32	0	0	
3	0	3	0	0	2	2	0	3	0	8	1	0	
4	0	13	2	0	15	3	2	6	0	30	8	1	
5	0	33	12	0	26	2	0	7	1	55	13	0	
LST=22													110
2	0	7	1	0	16	1	1	8	0	34	0	0	
3	0	4	0	0	4	3	0	5	0	12	2	0	
4	0	16	0	0	15	3	3	8	0	35	5	0	
5	0	34	14	0	21	3	0	7	1	62	18	0	

MONTH 2 REGION 15

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													90
2	0	2	0	0	16	1	1	13	0	31	1	0	
3	0	2	0	0	8	0	0	5	0	13	1	0	
4	0	11	3	0	10	5	0	9	0	20	9	0	
5	0	27	6	0	25	2	0	8	0	52	8	0	
LST= 4													85
2	0	1	0	0	10	3	3	12	0	27	1	0	
3	0	5	0	0	7	1	1	5	0	15	2	0	
4	0	16	1	0	14	3	1	10	0	31	7	0	
5	0	20	7	0	19	3	0	9	0	49	7	1	
LST= 7													80
2	0	6	0	0	17	5	2	14	0	30	3	0	
3	0	8	0	0	9	1	0	5	0	15	4	0	
4	0	21	1	0	22	5	1	8	0	40	9	0	
5	0	25	9	0	14	3	0	6	0	35	11	0	
LST=10													60
2	0	4	2	0	25	5	1	11	0	40	5	0	
3	0	4	2	0	5	4	2	8	0	9	8	0	
4	0	29	5	0	27	13	3	19	0	30	30	2	
5	0	31	7	0	20	7	0	10	0	31	19	2	
LST=13													55
2	0	6	1	0	14	11	3	11	0	29	7	1	
3	0	7	4	0	8	2	3	10	0	11	10	1	
4	0	22	3	0	27	12	0	21	1	34	23	2	
5	0	27	11	0	26	13	3	15	0	40	20	5	
LST=16													61
2	0	5	2	0	10	5	4	11	0	39	3	0	
3	0	5	1	0	5	2	1	3	0	9	4	0	
4	0	10	4	0	24	6	1	21	1	28	23	1	
5	0	25	13	0	26	14	2	17	0	41	25	2	
LST=19													80
2	0	6	2	0	19	1	2	11	0	33	4	0	
3	0	2	0	0	6	2	0	3	0	11	1	0	
4	0	11	0	0	16	8	1	13	0	33	8	0	
5	0	29	11	0	27	8	1	14	0	43	19	3	
LST=22													91
2	0	3	1	0	15	2	1	9	0	26	2	0	
3	0	2	1	0	5	0	1	3	0	10	1	0	
4	0	9	3	0	10	7	1	15	0	30	6	1	
5	0	26	8	0	28	9	1	8	3	53	13	0	

MONTH 3 REGION 15

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													122
2	0	1	0	0	9	2	5	11	0	36	0	0	
3	0	5	0	0	5	9	1	6	0	15	1	0	
4	0	12	2	0	19	5	6	22	0	37	13	1	
5	0	24	5	0	20	2	0	12	0	36	12	1	
LST= 4													112
2	0	4	2	0	19	1	2	17	0	45	2	0	
3	0	6	0	0	6	2	3	19	0	19	4	0	
4	0	8	2	0	20	4	4	16	0	34	10	0	
5	0	17	6	0	22	4	1	18	0	37	10	1	
LST= 7													95
2	0	6	3	0	14	4	1	19	0	37	5	0	
3	0	2	0	0	6	7	4	8	0	12	5	0	
4	0	14	6	0	32	14	5	22	0	34	23	4	
5	0	19	10	0	34	3	0	13	0	36	18	2	
LST=10													92
2	0	6	2	0	16	5	4	23	0	42	7	0	
3	0	3	2	0	7	3	5	8	0	12	8	0	
4	0	14	2	0	27	29	0	27	0	25	31	3	
5	0	16	10	0	27	5	1	12	0	33	16	2	
LST=13													86
2	0	4	1	0	12	9	0	21	0	40	2	0	
3	0	1	2	0	8	1	5	10	0	11	9	0	
4	0	12	1	0	23	17	7	33	0	35	29	0	
5	0	19	6	0	19	7	2	15	0	30	17	2	
LST=16													86
2	1	1	2	0	15	7	0	23	0	42	10	0	
3	0	1	0	0	11	2	1	11	0	10	9	0	
4	1	13	2	0	19	15	7	29	0	32	27	0	
5	0	19	11	0	22	4	1	20	4	30	18	3	
LST=19													82
2	0	3	0	0	18	9	4	30	0	52	6	0	
3	0	3	3	3	7	2	0	13	0	17	9	0	
4	0	15	1	0	20	7	2	27	1	20	25	1	
5	0	18	11	0	33	7	1	18	1	32	27	1	
LST=22													100
2	0	6	0	0	12	0	3	22	0	39	0	0	
3	0	5	0	0	7	2	0	8	0	10	3	0	
4	0	15	4	0	25	7	4	26	0	35	10	0	
5	0	18	7	0	20	6	0	11	1	55	17	0	

MONTH 4 REGION 15

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													87
2	0	7	6	0	22	5	4	24	0	40	16	0	
3	0	4	1	0	2	1	3	9	0	16	7	0	
4	0	15	7	0	28	9	8	11	0	20	26	2	
5	0	27	9	0	22	7	0	6	1	30	21	0	
LST= 4													85
2	0	8	0	0	16	5	7	14	0	30	6	0	
3	0	5	2	0	8	3	1	13	0	11	9	0	
4	0	16	13	0	26	9	7	22	0	28	25	5	
5	0	29	12	0	[illegible]	9	1	14	1	26	29	1	
LST= 7													96
2	0	9	3	0	11	8	5	25	0	37	12	0	
3	0	0	2	0	3	2	2	6	0	11	7	0	
4	0	18	10	0	27	14	3	21	0	29	29	4	
5	0	23	17	0	24	5	2	16	0	21	27	6	
LST=10													83
2	0	2	0	0	8	5	6	23	0	40	2	0	
3	0	2	2	0	7	5	2	19	0	9	4	1	
4	1	18	12	0	29	17	4	25	0	32	30	3	
5	0	26	9	0	27	9	1	18	0	26	27	2	
LST=13													92
2	0	3	6	0	10	6	0	26	0	46	5	1	
3	0	3	0	0	1	2	1	4	0	5	3	0	
4	1	15	10	0	29	13	3	27	0	21	31	5	
5	0	29	9	0	23	4	0	21	0	40	22	2	
LST=16													90
2	0	8	3	0	6	7	6	27	0	40	7	1	
3	0	3	1	0	4	7	2	7	0	10	7	0	
4	0	11	13	0	26	16	5	24	0	29	20	0	
5	0	23	7	0	20	5	1	14	0	29	23	1	
LST=19													90
2	1	8	6	0	11	4	0	25	0	40	10	1	
3	0	3	2	0	2	4	3	10	0	14	5	0	
4	1	19	0	0	23	13	3	23	0	24	39	2	
5	0	19	9	0	26	6	1	16	0	26	21	3	
LST=22													90
2	0	10	3	0	13	4	8	30	0	48	[illegible]	[illegible]	
3	0	4	2	0	6	5	0	10	0	[illegible]	[illegible]	1	
4	0	16	5	0	19	10	3	18	0	19	19	4	
5	0	23	11	0	29	7	1	16	0	[illegible]	29	2	

MONTH 5 REGION 15

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													30
2	0	10	1	0	2	13	3	12	0	29	8	0	
3	0	9	4	0	0	5	1	7	0	8	9	0	
4	0	40	13	0	26	25	4	26	0	23	47	5	
5	0	49	50	0	19	12	3	15	5	37	43	10	
LST= 4													44
2	0	14	3	0	4	12	10	9	0	20	9	2	
3	0	9	4	0	2	6	4	9	0	7	12	1	
4	1	41	15	0	10	22	5	21	0	25	39	6	
5	0	51	54	0	18	18	2	12	4	40	40	10	
LST= 7													43
2	0	12	6	0	7	17	7	15	0	34	13	1	
3	0	5	0	0	3	4	3	7	0	10	3	2	
4	0	36	13	0	14	18	6	14	0	28	28	5	
5	0	61	52	0	26	13	2	12	2	40	40	13	
LST=10													53
2	0	12	8	0	2	11	9	13	0	31	12	0	
3	1	6	5	0	1	5	2	5	0	6	5	3	
4	1	38	15	0	14	26	9	16	0	36	28	9	
5	0	71	48	0	16	15	1	14	1	31	49	12	
LST=13													45
2	1	12	6	0	4	7	9	12	0	29	11	0	
3	2	6	6	0	1	3	3	6	0	7	7	2	
4	1	48	17	0	16	24	5	30	3	40	33	10	
5	0	59	44	0	21	17	0	13	1	34	43	10	
LST=16													41
2	1	12	10	0	6	9	8	19	0	30	13	3	
3	0	10	2	0	3	1	5	6	0	8	5	3	
4	2	53	14	0	20	19	7	27	0	25	45	9	
5	0	54	46	0	19	14	0	13	1	42	40	8	
LST=19													44
2	0	12	6	0	1	10	5	19	0	37	8	0	
3	0	8	2	0	3	6	1	8	0	9	8	1	
4	2	51	12	0	18	28	5	27	0	21	43	9	
5	0	62	45	0	20	16	0	11	0	36	48	10	
LST=22													45
2	0	10	5	0	5	12	5	14	0	37	11	0	
3	0	11	4	0	2	7	1	6	0	6	8	3	
4	1	45	13	0	21	24	3	30	0	23	36	14	
5	0	53	41	0	19	8	0	9	0	36	37	6	

MONTH 6 REGION 15

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													40
2	0	8	2	0	2	9	10	17	0	30	7	0	
3	0	5	1	0	0	3	1	7	0	7	5	0	
4	0	33	12	0	8	28	7	18	0	28	22	11	
5	0	56	44	0	16	16	0	11	1	30	36	14	
LST= 4													33
2	0	3	1	0	0	17	14	14	0	39	5	0	
3	0	2	1	0	1	5	6	7	0	10	4	1	
4	1	35	8	0	7	31	8	25	0	32	31	7	
5	0	60	53	0	13	11	1	11	3	28	41	10	
LST= 7													38
2	0	9	1	0	2	13	19	23	0	39	8	1	
3	0	2	0	0	0	2	3	6	0	9	2	0	
4	1	43	14	0	9	32	9	25	0	32	32	12	
5	0	62	50	0	13	17	1	6	0	25	33	19	
LST=10													39
2	0	4	3	0	1	11	9	17	0	33	6	0	
3	0	1	1	0	0	3	6	5	0	10	5	0	
4	0	55	23	0	7	37	16	25	0	32	41	15	
5	1	60	49	0	12	19	1	10	0	24	41	15	
LST=13													42
2	0	9	6	0	1	14	16	22	0	30	12	2	
3	0	7	1	0	0	7	6	3	0	9	6	1	
4	1	48	19	0	8	31	5	24	0	27	36	11	
5	0	61	48	0	4	16	3	9	1	25	39	14	
LST=16													50
2	0	8	3	0	1	6	14	15	0	35	6	0	
3	0	10	3	0	1	3	2	7	0	15	4	1	
4	1	51	20	0	7	32	10	23	0	27	48	7	
5	0	41	38	0	7	12	1	7	2	25	29	8	
LST=19													49
2	0	11	6	0	4	11	12	24	0	33	16	1	
3	1	4	1	0	0	3	6	4	0	9	5	0	
4	0	40	16	0	10	37	9	23	0	19	25	22	
5	0	47	32	0	11	13	0	16	2	26	27	13	
LST=22													45
2	0	8	4	0	2	9	21	18	0	37	11	1	
3	0	2	2	0	3	10	4	12	0	10	10	1	
4	0	34	14	0	7	28	4	14	1	22	27	7	
5	0	43	39	0	14	17	0	17	0	24	39	9	

MONTH 7 REGION 15

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													21
2	1	8	1	0	2	17	17	13	0	34	11	1	
3	0	1	2	0	6	4	5	6	0	4	4	2	
4	0	33	18	0	2	46	14	28	0	20	33	18	
5	0	90	80	0	70	20	3	14	3	21	48	29	
LST= 4													21
2	0	7	1	0	1	15	11	15	0	38	6	0	
3	0	3	4	0	3	5	5	6	0	4	6	1	
4	1	36	15	0	5	46	9	25	0	21	27	20	
5	0	66	37	0	20	25	2	17	4	26	40	27	
LST= 7													35
2	0	4	2	0	3	14	13	16	0	32	10	0	
3	0	4	2	0	3	19	7	9	0	9	13	0	
4	0	33	13	0	5	35	6	19	3	15	32	10	
5	0	90	80	0	17	40	3	12	1	24	49	27	
LST=10													41
2	3	5	2	0	2	12	9	16	0	23	13	0	
3	0	10	1	0	3	6	4	12	0	4	9	3	
4	1	48	13	0	4	39	7	19	0	14	32	14	
5	1	84	47	0	14	39	2	11	2	20	52	26	
LST=13													37
2	2	6	4	0	2	17	11	20	0	31	11	3	
3	1	4	8	0	1	6	6	7	0	8	4	3	
4	1	47	12	0	4	37	4	30	1	19	38	16	
5	0	90	45	0	20	37	2	15	1	10	47	31	
LST=16													36
2	2	10	2	0	0	11	13	20	0	29	15	1	
3	1	7	0	0	2	4	4	6	0	9	8	1	
4	1	48	10	0	7	35	10	25	1	17	35	16	
5	0	88	43	0	21	39	1	17	0	22	43	32	
LST=19													37
2	1	9	9	0	2	12	15	10	0	15	8	1	
3	0	9	1	0	2	5	5	7	0	5	9	2	
4	0	42	12	0	7	48	12	26	1	20	30	16	
5	0	81	40	0	25	28	0	15	1	24	38	30	
LST=22													26
2	1	1	3	0	1	17	20	8	0	33	9	0	
3	0	6	6	0	2	7	3	9	0	6	11	1	
4	1	44	15	0	6	44	13	21	4	22	29	21	
5	0	87	46	0	10	29	1	17	3	20	41	31	

MONTH 8 REGION 15

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST= 1													27
2	0	6	2	0	5	13	12	16	0	30	9	0	
3	0	4	4	0	2	8	5	8	0	7	9	2	
4	0	30	11	0	6	37	6	21	0	20	27	12	
5	0	92	46	0	27	26	1	15	0	25	58	22	
LST= 4													29
2	0	4	4	0	2	14	15	17	0	26	12	2	
3	0	6	1	0	2	11	6	4	0	12	9	0	
4	0	38	15	0	11	49	10	29	0	22	37	15	
5	0	79	39	0	23	26	3	10	0	29	43	21	
LST= 7													24
2	0	9	4	0	1	11	16	12	0	31	11	0	
3	0	7	1	0	0	13	7	12	0	9	11	3	
4	1	39	12	0	9	28	13	21	0	26	37	11	
5	0	76	40	0	21	32	4	13	0	27	42	25	
LST=10													28
2	0	9	3	0	3	8	16	14	0	33	7	2	
3	1	7	4	0	1	11	8	9	0	7	14	2	
4	1	39	16	0	7	27	14	28	0	26	33	10	
5	0	84	45	0	17	29	1	7	1	28	50	10	
LST=13													23
2	0	11	4	0	2	17	20	9	0	28	15	0	
3	1	7	5	0	1	8	10	5	0	8	10	3	
4	1	53	22	0	4	39	21	22	0	21	41	19	
5	0	90	32	0	19	22	2	11	0	23	47	19	
LST=16													29
2	0	17	3	0	3	19	16	13	0	27	18	1	
3	1	8	2	0	2	15	7	11	0	11	12	3	
4	0	40	15	0	4	39	15	19	0	29	27	16	
5	0	89	41	0	16	29	0	12	0	27	45	25	
LST=19													33
2	0	8	2	0	1	14	15	9	0	30	8	1	
3	0	9	2	0	2	7	0	7	0	6	13	1	
4	1	37	11	0	9	39	8	31	0	20	32	19	
5	0	87	35	1	10	24	4	13	0	26	45	21	
LST=22													31
2	0	8	3	0	0	13	12	15	0	33	7	0	
3	0	6	6	0	1	8	0	6	0	8	11	1	
4	0	33	12	0	9	37	7	21	0	10	32	14	
5	0	88	41	0	20	26	3	12	0	31	59	13	

MONTH 9 REGION 15

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													64
2	0	12	2	0	4	15	11	9	0	43	5	0	
3	0	10	2	0	2	3	1	5	0	7	8	0	
4	0	33	5	0	10	18	4	8	0	24	28	2	
5	0	100	29	0	17	22	0	4	3	57	47	8	
LST# 4													61
2	1	13	1	0	4	13	9	11	0	36	9	0	
3	0	8	0	0	2	4	3	4	0	9	6	0	
4	0	47	11	0	12	26	4	11	0	25	38	6	
5	0	88	23	0	22	12	1	8	3	38	46	9	
LST# 7													49
2	0	21	2	0	8	11	9	9	0	27	12	3	
3	0	5	1	0	1	6	5	6	0	5	8	1	
4	0	54	7	0	13	30	9	16	0	27	33	13	
5	0	104	32	0	18	26	2	17	0	39	50	20	
LST#10													35
2	0	20	0	0	4	9	4	15	0	24	18	0	
3	0	8	1	0	1	8	4	7	0	8	9	1	
4	0	45	9	0	11	28	13	25	0	19	35	13	
5	0	101	37	0	14	26	3	18	3	29	55	20	
LST#13													34
2	0	13	7	0	1	7	12	9	0	29	7	2	
3	0	13	3	0	1	9	2	13	0	9	13	2	
4	1	65	13	0	11	44	15	24	0	29	41	20	
5	0	102	31	0	17	28	3	18	2	37	38	29	
LST#16													28
2	0	15	2	0	2	14	8	5	0	16	12	2	
3	0	10	0	0	0	3	5	5	0	9	7	0	
4	0	59	9	0	8	32	15	32	0	24	41	16	
5	0	102	38	0	22	27	3	17	4	35	43	30	
LST#19													37
2	0	24	3	0	3	14	17	9	0	32	19	0	
3	0	15	2	0	4	8	5	7	0	6	10	5	
4	0	53	7	0	13	27	7	14	0	18	35	11	
5	0	112	39	0	25	27	3	15	2	37	51	28	
LST#22													39
2	0	15	0	0	6	16	10	12	0	41	9	0	
3	0	7	1	0	2	3	2	4	0	8	4	1	
4	0	43	8	0	8	27	3	9	0	17	27	9	
5	0	99	34	0	26	21	0	11	4	39	57	14	

MONTH 10 REGION 15

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													93
2	0	13	1	0	2	6	2	8	1	27	3	0	
3	0	10	0	0	1	2	0	4	0	13	2	0	
4	1	33	4	0	6	12	0	6	0	31	19	1	
5	0	102	16	0	12	10	1	5	1	87	27	2	
LST# 4													74
2	0	17	0	0	6	3	0	4	0	28	1	0	
3	0	3	0	0	2	5	0	3	0	9	2	0	
4	0	24	2	0	5	13	2	8	0	27	12	1	
5	0	102	14	0	15	8	0	4	3	88	24	3	
LST# 7													41
2	0	14	2	0	10	5	2	10	0	29	7	0	
3	0	11	0	0	4	7	2	5	0	10	8	1	
4	0	50	7	0	17	19	3	17	1	32	29	6	
5	0	127	18	0	27	19	0	11	2	73	55	7	
LST#10													32
2	0	21	0	0	8	6	3	10	0	24	12	0	
3	0	12	0	0	4	6	5	4	0	8	7	3	
4	0	72	9	0	18	20	10	18	0	16	43	15	
5	0	122	24	0	21	18	1	13	1	51	42	21	
LST#13													29
2	0	24	2	0	4	6	10	12	0	30	14	0	
3	0	9	0	0	4	7	3	8	0	8	10	1	
4	0	79	8	0	17	35	11	24	0	17	46	21	
5	0	125	27	0	22	19	3	19	2	51	45	24	
LST#16													33
2	0	23	1	0	7	11	7	15	0	28	18	0	
3	0	5	1	0	2	3	2	5	0	6	6	0	
4	0	58	4	0	14	28	3	18	0	17	30	15	
5	0	121	24	0	19	13	2	14	2	59	51	11	
LST#19													52
2	0	20	1	0	9	10	7	15	0	46	8	0	
3	0	10	0	0	0	1	0	3	0	6	4	0	
4	0	54	2	0	9	13	2	10	0	28	22	6	
5	0	118	21	0	23	16	3	14	3	66	48	12	
LST#22													70
2	0	11	0	0	5	4	5	10	0	77	4	0	
3	0	9	1	0	2	1	1	1	0	11	2	0	
4	0	36	2	0	4	11	1	6	0	27	15	1	
5	0	109	22	0	13	14	1	7	2	78	36	6	

MONTH 11 REGION 15

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													112
2	0	11	1	0	0	6	1	7	0	26	0	0	
3	0	8	0	0	3	2	0	1	0	10	2	0	
4	0	29	2	0	13	8	1	8	0	24	17	1	
5	0	61	18	0	12	7	0	8	2	72	25	2	
LST# 4													105
2	0	14	0	0	3	5	2	7	0	27	2	0	
3	0	11	0	0	6	0	2	4	0	15	4	0	
4	0	30	4	0	5	9	0	6	0	29	11	1	
5	0	77	21	0	14	8	0	7	0	64	27	3	
LST# 7													102
2	0	14	2	0	5	4	5	4	0	30	4	0	
3	0	11	1	0	3	3	0	1	0	11	4	0	
4	0	29	3	0	12	10	1	8	0	28	14	2	
5	0	77	14	0	17	10	0	3	0	67	24	2	
LST#10													77
2	0	14	3	0	10	6	6	8	0	35	6	0	
3	0	15	0	0	2	4	4	5	0	8	8	2	
4	0	58	3	0	12	15	1	9	0	24	30	3	
5	0	80	14	0	22	15	0	11	1	53	33	8	
LST#13													61
2	0	26	2	0	10	10	7	11	0	45	10	1	
3	0	11	2	0	4	5	1	4	0	10	7	1	
4	0	25	6	0	12	2	2	10	0	15	17	6	
5	0	95	23	0	30	16	1	17	1	53	53	8	
LST#16													72
2	1	19	2	0	11	9	3	10	1	41	6	1	
3	0	6	2	0	2	0	0	2	0	8	2	0	
4	0	49	3	0	13	15	3	11	0	38	19	6	
5	0	73	17	0	16	12	0	9	1	58	29	4	
LST#19													108
2	0	16	2	0	3	6	1	7	0	31	2	0	
3	0	6	0	0	3	3	2	2	0	10	3	0	
4	0	33	1	0	12	10	1	10	0	30	17	1	
5	0	78	17	0	12	9	0	4	0	56	29	2	
LST#22													100
2	0	15	0	0	5	6	3	5	0	32	1	0	
3	0	5	0	0	0	3	2	3	0	7	3	0	
4	0	36	4	0	11	5	2	9	0	32	16	1	
5	0	75	14	0	16	9	0	6	1	65	42	4	

MONTH 12 REGION 15

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													137
2	0	9	2	0	12	7	2	6	0	38	0	0	
3	0	4	1	0	3	2	0	2	0	12	0	0	
4	0	19	3	0	18	5	0	6	0	39	6	0	
5	0	51	7	0	9	3	0	5	1	56	10	0	
LST# 4													149
2	0	10	1	0	8	4	1	9	0	32	0	0	
3	0	4	1	0	4	0	1	1	0	9	1	0	
4	0	19	4	0	12	4	0	6	0	31	7	0	
5	0	51	8	0	16	4	0	6	0	67	9	0	
LST# 7													139
2	0	13	1	0	11	3	2	5	0	33	1	0	
3	0	8	2	0	11	4	1	5	0	19	6	0	
4	0	20	3	0	12	3	1	2	0	35	5	0	
5	0	43	7	0	16	4	0	1	0	61	5	0	
LST#10													121
2	0	18	1	0	22	4	5	7	0	53	2	0	
3	0	4	2	0	7	3	0	3	0	15	2	0	
4	0	25	6	0	18	8	0	5	0	33	13	1	
5	0	40	10	0	10	2	0	2	0	52	6	0	
LST#13													96
2	0	20	1	0	32	1	5	7	0	58	4	0	
3	1	7	2	0	8	3	0	5	0	12	7	0	
4	0	24	4	0	22	9	3	8	0	36	17	0	
5	0	36	13	0	19	6	0	6	1	59	11	0	
LST#16													125
2	0	14	3	0	17	1	4	14	0	51	1	0	
3	0	5	2	0	9	3	0	1	0	12	4	0	
4	0	19	2	0	15	2	1	4	0	29	7	0	
5	0	43	10	0	19	6	0	2	1	65	8	0	
LST#19													146
2	0	6	2	0	12	1	2	8	0	31	0	0	
3	0	10	0	0	4	3	0	2	0	15	2	0	
4	0	9	5	0	16	3	0	2	2	33	2	0	
5	0	46	11	0	13	5	0	8	1	54	15	0	
LST#22													141
2	0	11	0	0	9	6	1	5	0	32	0	0	
3	0	6	1	0	2	1	0	4	0	12	1	0	
4	0	17	8	0	20	3	0	4	1	35	9	0	
5	0	49	12	0	18	4	0	7	2	58	39	0	

MONTH 1 REGION 24

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													21
2	1	8	1	0	2	17	17	13	0	14	11	1	
3	0	1	2	0	0	8	5	6	0	8	8	2	
4	0	33	18	0	2	48	14	28	0	20	39	18	
5	0	90	40	0	20	28	3	14	3	21	44	29	
LST# 4													21
2	0	7	1	0	1	15	11	15	4	30	8	0	
3	0	3	2	0	3	5	5	6	0	9	8	1	
4	1	30	15	0	5	46	9	25	0	21	27	20	
5	0	86	37	0	20	25	2	12	4	24	40	27	
LST# 7													35
2	0	4	2	0	3	14	13	18	0	32	10	0	
3	0	4	2	0	3	18	7	9	0	9	13	0	
4	0	33	13	0	5	35	6	19	0	15	32	10	
5	0	90	40	0	17	40	3	12	1	24	48	21	
LST#10													41
2	3	5	2	0	2	12	9	18	0	23	13	0	
3	0	10	1	0	3	6	4	12	0	4	9	3	
4	1	40	13	0	4	39	7	19	0	14	32	14	
5	1	84	47	0	19	39	2	11	2	20	52	26	
LST#13													37
2	2	6	4	0	2	17	11	20	0	31	11	3	
3	1	4	0	0	1	5	6	7	0	6	4	3	
4	1	47	12	0	4	37	4	30	1	17	34	15	
5	0	90	45	0	20	37	2	15	1	16	47	31	
LST#16													36
2	2	10	2	0	4	11	13	20	0	24	15	1	
3	1	7	0	0	2	8	4	6	0	9	8	1	
4	1	45	16	0	7	35	10	25	1	17	35	16	
5	0	88	43	0	21	37	1	17	0	22	43	32	
LST#19													37
2	1	5	5	0	2	12	15	14	0	35	8	1	
3	0	9	1	0	2	5	5	7	0	5	9	2	
4	0	42	12	0	7	49	12	26	1	20	38	15	
5	0	81	40	0	25	28	0	15	1	22	38	30	
LST#22													24
2	1	1	3	0	1	17	20	8	0	35	4	0	
3	0	6	4	0	2	7	3	9	0	6	11	1	
4	1	44	15	0	4	44	13	23	0	22	29	21	
5	0	87	44	0	16	29	1	17	3	20	41	31	

MONTH 2 REGION 24

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													27
2	0	6	2	0	5	13	12	16	0	36	9	0	
3	0	4	4	0	2	8	5	8	0	7	4	2	
4	0	30	11	0	6	37	4	21	0	20	27	12	
5	0	92	46	0	27	26	1	15	0	25	58	22	
LST# 4													29
2	0	4	4	0	2	14	15	17	0	26	12	2	
3	0	6	1	0	2	11	6	4	0	12	9	0	
4	0	38	15	0	11	40	10	28	0	22	37	15	
5	0	79	39	0	23	26	3	10	0	29	43	21	
LST# 7													24
2	0	9	4	0	1	11	16	12	0	31	11	0	
3	0	7	1	0	0	13	7	12	0	9	11	3	
4	1	39	12	0	9	28	13	21	0	26	32	11	
5	0	76	40	0	21	33	4	13	0	27	42	25	
LST#10													28
2	0	9	3	0	3	8	16	14	0	33	7	2	
3	1	7	4	0	1	11	6	9	0	7	14	2	
4	1	30	16	0	7	27	14	29	0	26	33	10	
5	0	89	45	0	17	29	1	7	1	26	50	19	
LST#13													23
2	0	11	4	0	2	12	20	9	0	28	15	0	
3	1	7	5	0	1	8	10	5	0	4	10	3	
4	1	53	22	0	4	39	21	22	0	21	41	19	
5	0	90	32	0	19	22	2	11	0	23	47	17	
LST#16													24
2	0	17	3	0	3	10	16	13	0	27	18	1	
3	1	8	2	0	2	13	7	11	0	11	12	3	
4	0	40	15	0	4	38	15	19	0	26	27	15	
5	0	89	41	0	16	29	6	12	0	27	45	25	
LST#19													33
2	0	8	2	0	1	14	15	9	0	30	8	1	
3	0	9	2	0	2	7	3	7	0	4	13	1	
4	1	37	11	0	9	39	8	31	0	26	32	15	
5	0	87	35	0	18	28	4	13	0	26	45	21	
LST#22													31
2	0	4	3	0	0	13	12	15	0	33	7	0	
3	0	6	4	0	1	8	6	6	0	6	11	1	
4	0	33	12	0	9	37	7	21	0	16	32	12	
5	0	88	41	0	20	26	3	12	0	31	59	13	

MONTH 3 REGION 24

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													64
2	0	12	2	0	4	15	11	9	0	43	5	0	
3	0	10	2	0	2	3	1	5	0	7	8	0	
4	0	33	5	0	10	19	4	8	0	24	24	2	
5	0	100	24	0	17	22	0	4	3	57	47	8	
LST# 4													41
2	1	13	1	0	6	13	4	11	0	36	9	0	
3	0	8	0	0	2	0	3	4	0	9	6	0	
4	0	47	11	0	12	26	4	11	0	25	39	6	
5	0	88	23	0	22	12	1	8	3	36	46	9	
LST# 7													49
2	0	21	2	0	8	11	9	9	0	27	12	3	
3	0	5	1	0	1	6	5	6	0	5	4	1	
4	0	54	7	0	13	34	9	18	0	27	33	13	
5	0	104	32	0	18	29	2	17	0	34	58	20	
LST#10													35
2	0	20	0	0	4	4	4	15	0	24	14	0	
3	0	8	1	0	1	9	4	7	0	9	9	1	
4	0	45	9	0	11	28	13	23	0	19	35	13	
5	0	101	37	0	14	26	3	18	3	29	55	20	
LST#13													34
2	0	13	7	0	1	7	12	9	0	24	7	2	
3	0	13	3	0	1	9	2	13	0	9	13	2	
4	1	65	13	0	11	40	15	20	0	29	41	20	
5	0	102	31	0	17	28	3	19	2	37	38	29	
LST#16													29
2	0	15	2	0	2	14	6	4	0	16	12	2	
3	0	10	0	0	0	3	5	5	0	9	7	0	
4	0	59	9	0	8	32	15	32	0	24	41	19	
5	0	102	38	0	22	27	3	17	4	35	43	30	
LST#19													37
2	0	28	3	0	3	14	17	9	0	32	19	0	
3	0	15	2	0	4	9	5	7	0	6	10	5	
4	0	53	7	0	13	27	7	14	0	10	35	11	
5	0	112	39	0	25	27	3	15	2	37	51	28	
ST#22													39
2	0	15	0	0	6	16	10	12	0	41	9	0	
3	0	7	1	0	2	3	2	4	0	4	4	1	
4	0	43	8	0	4	27	3	9	0	17	27	9	
5	0	99	34	0	26	21	0	11	4	34	57	14	

MONTH 4 REGION 24

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													45
2	0	13	1	0	2	6	2	8	1	27	3	0	
3	0	10	0	0	1	2	0	4	0	13	2	0	
4	1	33	4	0	6	12	0	6	0	31	14	1	
5	0	102	16	0	12	10	1	5	1	87	27	2	
LST# 4													74
2	0	17	0	0	6	3	0	4	0	28	1	0	
3	0	3	0	0	2	5	0	3	0	4	2	0	
4	0	24	2	0	5	13	2	8	0	27	12	1	
5	0	102	14	0	15	8	0	4	3	86	24	3	
LST# 7													41
2	0	14	2	0	10	5	2	10	0	29	7	0	
3	0	11	0	0	4	7	2	5	0	10	8	1	
4	0	50	7	0	17	19	3	17	1	32	29	9	
5	0	127	18	0	27	19	0	11	2	73	55	7	
LST#10													32
2	0	21	0	0	8	6	3	10	0	24	12	0	
3	0	12	0	0	4	6	5	4	0	8	7	3	
4	0	72	9	0	15	20	13	19	0	16	43	15	
5	0	122	24	0	21	18	1	13	1	51	42	21	
LST#13													27
2	0	24	2	0	4	6	10	12	0	30	14	0	
3	0	9	0	0	4	7	3	8	0	6	10	1	
4	0	79	8	0	17	35	11	20	0	17	48	21	
5	0	125	27	0	22	19	3	19	2	51	45	24	
LST#16													34
2	0	23	1	0	7	11	7	15	0	28	18	0	
3	0	5	1	0	2	3	2	5	0	6	6	0	
4	0	59	4	0	14	29	3	18	0	17	30	15	
5	0	121	24	0	19	13	2	14	2	59	51	11	
LST#19													52
2	0	20	1	0	9	10	7	15	0	46	9	0	
3	0	10	0	0	0	1	0	3	0	4	4	0	
4	0	34	2	0	9	13	2	10	0	28	22	6	
5	0	118	21	0	23	16	3	14	3	66	48	12	
LST#22													70
2	0	11	0	0	5	4	5	10	0	27	4	0	
3	0	9	1	0	2	1	1	1	0	11	2	0	
4	0	36	2	0	4	11	1	6	0	27	15	1	
5	0	109	22	0	13	14	1	7	2	78	38	6	

MONTH 5 REGION 24

LST#	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													112
2	0	11	1	0	0	8	1	7	0	26	8	0	
3	0	8	0	0	3	2	0	1	0	10	2	0	
4	0	29	2	0	13	8	1	8	0	24	17	1	
5	0	61	10	0	12	7	0	8	2	72	25	2	
LST# 4													106
2	0	14	0	0	3	5	2	7	0	27	2	0	
3	0	11	0	0	6	8	2	4	0	15	4	0	
4	0	30	4	0	5	9	0	6	0	29	11	1	
5	0	77	21	0	14	8	0	7	0	44	27	3	
LST# 7													102
2	0	18	2	0	5	4	5	4	0	30	4	0	
3	0	11	1	0	3	3	0	1	0	11	4	0	
4	0	29	3	0	12	10	1	6	0	28	14	2	
5	0	77	14	0	17	10	0	3	0	67	24	2	
LST#10													77
2	0	14	3	0	10	6	6	8	0	35	6	0	
3	0	15	0	0	2	4	4	5	0	8	8	2	
4	0	54	3	0	12	15	1	8	0	24	30	3	
5	0	80	14	0	22	15	0	11	1	53	33	8	
LST#13													61
2	0	26	2	0	10	10	7	11	0	43	10	1	
3	0	11	2	0	4	5	1	4	0	10	7	1	
4	0	25	6	0	12	12	2	10	0	15	17	6	
5	0	95	23	0	30	16	1	17	1	53	53	8	
LST#16													72
2	1	19	2	0	11	9	3	10	1	41	6	1	
3	0	6	2	0	2	0	0	2	0	8	2	0	
4	0	49	3	0	13	15	3	11	0	30	19	6	
5	0	73	17	0	16	12	0	9	1	50	29	4	
LST#19													100
2	0	16	2	0	3	6	1	7	0	31	2	0	
3	0	6	0	0	3	3	2	2	0	10	3	0	
4	0	33	1	0	12	19	1	19	0	30	17	1	
5	0	78	17	0	12	9	0	4	0	56	29	2	
LST#22													103
2	0	15	0	0	5	6	3	5	0	32	1	0	
3	0	5	0	0	0	3	2	3	0	7	3	0	
4	0	36	4	0	11	5	2	9	0	32	16	1	
5	0	75	14	0	16	9	0	8	1	85	27	4	

MONTH REGION 24

LST#	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													117
2	0	9	2	0	12	7	2	6	0	38	0	0	
3	0	4	1	0	3	2	0	2	0	12	0	0	
4	0	19	3	0	18	5	0	8	0	39	6	0	
5	0	51	7	0	9	3	0	5	1	56	10	0	
LST# 4													144
2	0	10	1	0	8	4	1	8	0	52	8	0	
3	0	4	1	0	4	8	1	1	0	9	1	0	
4	0	19	4	0	12	4	0	6	0	31	7	0	
5	0	51	0	0	16	4	0	6	0	67	9	0	
LST# 7													137
2	0	13	1	0	11	3	2	5	0	33	1	0	
3	0	8	2	0	11	4	1	5	0	19	6	0	
4	0	24	3	0	12	3	1	2	0	35	5	0	
5	0	43	7	0	16	4	0	1	0	61	5	0	
LST#10													121
2	0	18	1	0	22	4	5	7	0	53	2	0	
3	0	4	2	0	7	3	0	3	0	15	2	0	
4	0	25	6	0	16	8	0	5	0	33	13	1	
5	0	40	10	0	10	2	0	2	0	52	8	0	
LST#13													96
2	0	20	1	0	32	1	5	7	0	59	4	0	
3	1	7	2	0	8	3	0	5	0	12	7	0	
4	0	24	4	0	22	9	3	8	0	36	17	0	
5	0	36	13	0	19	6	0	6	1	59	11	0	
LST#16													123
2	0	14	3	0	17	1	4	14	0	51	1	0	
3	0	5	2	0	9	3	0	1	0	12	4	0	
4	0	19	2	0	15	2	1	4	0	29	7	0	
5	0	43	10	0	19	6	0	2	1	65	8	0	
LST#19													145
2	0	6	2	0	12	1	2	8	0	31	8	0	
3	0	10	0	0	4	3	0	2	0	15	2	0	
4	0	9	5	0	16	3	0	2	2	33	2	0	
5	0	46	11	0	13	5	0	8	1	54	15	0	
LST#22													131
2	0	11	0	0	9	6	1	5	0	32	0	0	
3	0	6	1	0	2	1	0	4	0	12	1	0	
4	0	17	8	0	20	3	0	4	1	35	9	0	
5	0	49	12	0	19	4	0	7	2	58	17	0	

MONTH 7 REGION 24

LST#	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													127
2	0	2	0	0	16	3	1	8	0	26	2	0	
3	0	5	1	0	4	1	1	2	0	14	1	0	
4	0	10	1	0	13	2	0	7	0	19	8	0	
5	0	35	14	0	21	4	0	3	0	57	10	0	
LST# 4													117
2	0	11	0	0	15	1	0	9	0	53	2	0	
3	0	2	1	0	4	2	0	5	0	17	1	0	
4	0	4	5	0	9	3	1	7	0	27	1	0	
5	0	36	10	0	24	3	0	3	1	43	7	0	
LST# 7													102
2	0	10	1	0	15	5	1	12	0	42	1	0	
3	0	3	1	0	5	2	1	4	0	14	1	0	
4	0	10	3	0	10	7	0	8	0	32	5	0	
5	0	34	15	0	27	2	1	2	0	60	9	1	
LST#10													83
2	0	11	1	0	25	3	2	11	0	52	1	0	
3	0	1	0	0	4	3	1	3	0	8	3	0	
4	0	25	4	0	20	8	1	15	0	44	12	1	
5	0	37	14	0	17	3	0	8	0	52	12	1	
LST#13													67
2	0	5	2	0	26	4	2	15	0	47	2	0	
3	0	12	0	0	12	4	1	5	0	23	4	1	
4	0	24	6	0	25	4	2	8	0	42	13	2	
5	0	31	12	0	23	3	0	10	2	57	12	0	
LST#16													95
2	0	9	1	0	23	3	1	17	0	50	2	0	
3	0	8	2	0	6	4	1	3	0	9	6	1	
4	0	19	3	0	13	7	2	8	0	32	11	1	
5	0	30	11	0	25	3	0	4	2	51	12	0	
LST#19													113
2	0	7	0	0	13	1	1	10	0	32	8	0	
3	0	3	0	0	2	2	0	3	0	8	1	0	
4	0	13	2	0	15	3	2	6	0	36	4	1	
5	0	33	12	0	26	2	0	7	1	55	13	0	
LST#22													119
2	0	7	1	0	16	1	1	8	0	34	0	0	
3	0	4	0	0	4	3	0	5	0	12	2	0	
4	0	16	0	0	15	3	3	8	0	35	5	0	
5	0	36	18	0	21	3	0	7	1	82	10	0	

MONTH 8 REGION 24

LST#	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													97
2	0	2	0	0	16	1	1	13	0	31	1	0	
3	0	2	0	0	8	0	0	5	0	13	1	0	
4	0	11	3	0	10	5	0	9	0	20	9	0	
5	0	27	6	0	25	2	0	8	0	52	8	0	
LST# 4													95
2	0	1	0	0	10	3	3	12	0	27	1	0	
3	0	5	0	0	7	1	1	5	0	15	2	0	
4	0	16	1	0	14	3	1	10	0	31	7	0	
5	0	28	7	0	19	3	0	9	0	49	7	1	
LST# 7													93
2	0	6	0	0	17	5	2	14	0	30	3	0	
3	0	8	0	0	4	1	0	5	0	15	4	0	
4	0	21	1	0	22	5	1	8	0	40	9	0	
5	0	25	9	0	14	3	0	8	0	35	11	0	
LST#10													80
2	0	4	2	0	25	5	1	13	0	40	5	0	
3	0	4	2	0	5	4	2	5	0	9	8	0	
4	0	29	5	0	27	13	3	19	0	30	30	2	
5	0	31	7	0	20	7	0	10	0	31	19	2	
LST#13													55
2	0	6	1	0	14	11	3	11	0	29	7	1	
3	0	7	4	0	6	2	3	10	0	11	12	1	
4	0	22	3	0	27	17	0	21	1	34	23	2	
5	0	27	11	0	26	13	3	15	0	40	20	5	
LST#16													61
2	0	5	2	0	18	5	4	11	0	39	3	0	
3	0	5	1	0	5	2	1	3	0	4	0	0	
4	0	18	4	0	24	8	1	21	1	20	23	1	
5	0	25	13	0	26	10	2	17	0	41	25	2	
LST#19													80
2	0	6	2	0	19	1	2	11	0	33	4	0	
3	0	2	0	0	6	2	0	3	0	11	1	0	
4	0	11	0	0	16	8	1	13	0	33	8	0	
5	0	29	11	0	27	8	1	14	0	43	19	3	
LST#22													91
2	0	3	1	0	14	2	1	9	0	26	2	0	
3	0	2	1	0	5	0	1	1	0	10	1	0	
4	0	9	3	0	10	7	1	15	0	20	6	1	
5	0	26	8	0	26	5	1	8	0	53	13	0	

MONTH 9 REGION 24

		CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1														122
	2	0	3	0	0	9	2	5	17	0	36	8	0	
	3	0	5	0	0	5	0	1	6	0	15	1	0	
	4	0	12	2	0	19	5	6	22	0	17	13	1	
	5	0	24	5	0	20	2	0	12	0	46	12	1	
LST# 4														112
	2	0	4	2	0	19	3	2	19	0	45	7	0	
	3	0	6	0	0	6	2	3	10	0	19	4	0	
	4	0	8	2	0	20	4	4	16	0	34	10	0	
	5	0	17	6	0	22	4	1	10	0	37	10	1	
LST# 7														95
	2	0	6	3	0	14	4	1	19	0	37	5	0	
	3	0	2	0	0	6	2	4	8	0	12	5	0	
	4	0	14	6	0	32	14	5	22	0	34	23	4	
	5	0	18	10	0	34	3	0	13	0	36	18	2	
LST#10														92
	2	0	6	2	0	16	5	4	23	0	42	7	0	
	3	0	3	2	0	7	3	5	8	0	12	8	0	
	4	0	14	2	0	27	20	6	27	0	25	31	3	
	5	0	16	10	0	27	5	1	12	0	35	16	2	
LST#13														86
	2	0	4	1	0	12	8	6	21	0	48	7	0	
	3	0	1	2	0	8	3	5	10	0	11	4	0	
	4	0	12	1	0	23	17	7	33	0	35	29	0	
	5	0	19	6	0	19	7	2	15	0	30	17	2	
LST#16														86
	2	1	8	2	0	15	7	6	23	0	42	10	0	
	3	0	3	0	0	11	2	1	11	0	10	9	0	
	4	1	13	2	0	19	15	7	29	0	32	27	0	
	5	0	19	11	0	22	4	1	20	2	34	18	3	
LST#19														82
	2	0	3	0	0	18	9	4	30	0	52	6	0	
	3	0	5	0	0	7	2	0	13	0	17	5	0	
	4	0	15	1	0	28	7	2	27	1	28	25	1	
	5	0	18	11	0	33	7	1	19	1	32	27	1	
LST#22														109
	2	0	6	0	0	12	4	3	22	0	34	4	0	
	3	0	5	0	0	7	2	0	8	0	16	3	0	
	4	0	15	4	0	23	7	4	26	0	35	16	4	
	5	0	18	7	0	24	9	0	13	1	33	17	0	

MONTH 10 REGION 24

		CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1														87
	2	0	7	6	0	22	3	4	24	0	48	10	0	
	3	0	4	1	0	2	1	3	9	0	16	2	0	
	4	0	15	7	0	28	9	8	11	0	20	26	2	
	5	0	27	9	0	22	7	0	6	1	30	21	0	
LST# 4														85
	2	0	8	0	0	16	5	7	14	0	38	6	0	
	3	0	5	2	0	8	3	1	10	0	11	9	0	
	4	0	16	13	0	26	9	7	22	0	28	25	5	
	5	0	29	12	0	21	9	1	14	1	26	29	1	
LST# 7														86
	2	0	9	3	0	11	8	5	25	0	37	12	0	
	3	0	0	2	0	3	2	2	6	0	11	2	0	
	4	0	18	14	0	27	14	3	23	0	24	29	4	
	5	0	23	17	0	24	5	2	16	0	21	27	4	
LST#10														83
	2	0	2	0	0	8	5	6	23	0	40	7	0	
	3	0	2	2	0	7	5	2	10	0	9	8	1	
	4	1	18	12	0	29	12	4	25	0	32	30	5	
	5	0	26	9	0	27	5	1	18	0	26	27	2	
LST#13														82
	2	0	3	6	0	10	6	8	26	0	46	5	1	
	3	0	3	0	0	1	2	1	4	0	5	3	0	
	4	1	15	10	0	29	13	3	27	0	21	31	5	
	5	0	29	9	0	23	6	0	23	0	40	22	2	
LST#16														93
	2	0	8	3	0	6	7	6	27	0	40	7	1	
	3	0	3	1	0	4	7	2	7	0	10	7	0	
	4	0	11	13	0	24	16	5	24	0	29	20	8	
	5	0	23	7	0	28	5	1	14	0	29	23	1	
LST#19														90
	2	1	8	6	0	11	4	8	25	0	40	10	1	
	3	0	3	2	0	2	4	3	10	0	14	5	0	
	4	1	19	8	0	23	13	3	23	0	24	30	2	
	5	0	19	9	0	26	6	1	16	0	26	21	3	
LST#22														93
	2	0	14	3	0	13	4	8	30	0	48.	12	0	
	3	0	4	2	0	6	5	0	10	0	8	8	1	
	4	0	14	5	0	19	10	3	18	0	19	19	4	
	5	0	23	11	0	29	7	1	10	0	25	25	2	

MONTH 11 REGION 24

		CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1														39
	2	0	14	1	0	2	13	3	12	0	27	8	0	
	3	0	9	4	0	0	5	1	7	0	8	9	0	
	4	0	40	13	0	24	25	4	26	0	23	47	5	
	5	0	49	50	0	19	12	3	15	5	37	43	10	
LST# 4														44
	2	0	14	3	0	4	12	10	9	0	26	9	2	
	3	0	9	4	0	2	6	4	9	0	7	12	1	
	4	1	41	15	0	16	22	5	21	0	25	39	6	
	5	0	51	54	0	18	10	2	12	4	40	40	10	
LST# 7														45
	2	0	12	6	0	.7	17	7	15	0	34	13	1	
	3	0	9	0	0	3	4	3	7	0	10	3	2	
	4	0	36	13	0	14	18	6	14	0	26	28	5	
	5	0	61	52	0	26	13	2	12	2	46	40	13	
LST#10														53
	2	0	12	8	0	2	11	9	13	0	31	12	0	
	3	1	6	5	0	1	5	2	5	0	6	5	3	
	4	1	38	15	0	14	26	9	16	0	36	28	9	
	5	0	71	40	0	16	15	1	14	1	31	49	12	
LST#13														45
	2	1	12	6	0	4	7	9	12	0	29	11	0	
	3	2	6	6	0	1	3	3	6	0	7	7	2	
	4	1	44	17	0	16	28	5	39	0	40	33	15	
	5	0	59	44	0	21	12	0	13	1	34	43	10	
LST#16														41
	2	1	12	10	0	6	9	4	19	0	30	13	3	
	3	0	10	2	0	3	1	5	6	0	8	5	3	
	4	2	53	14	0	20	19	7	27	0	25	45	9	
	5	0	54	46	0	19	14	0	13	1	42	40	8	
LST#19														44
	2	0	12	6	0	1	10	5	19	0	37	8	0	
	3	0	8	2	0	3	6	1	8	0	9	8	1	
	4	2	51	12	0	18	20	5	27	0	21	43	9	
	5	0	62	45	0	20	16	0	11	0	36	44	10	
LST#22														45
	2	0	14	5	0	5	12	5	14	0	37	11	0	
	3	0	11	4	0	2	7	1	6	0	6	8	3	
	4	1	45	13	0	21	24	3	30	0	23	36	14	
	5	0	53	41	0	19	8	0	9	0	18	37	6	

MONTH 12 REGION 24

		CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1														44
	2	0	4	2	0	2	9	18	17	0	36	7	0	
	3	0	5	1	0	0	3	1	7	0	7	5	0	
	4	0	33	12	0	8	28	7	18	0	28	22	11	
	5	0	56	44	0	16	16	0	11	1	30	36	14	
LST# 4														33
	2	0	3	1	0	0	17	14	14	0	19	5	0	
	3	0	2	1	0	1	5	6	7	0	10	4	1	
	4	1	35	8	0	7	33	8	25	0	32	31	7	
	5	0	68	53	0	13	11	1	11	3	26	41	16	
LST# 7														34
	2	0	9	1	0	2	13	10	23	0	39	8	1	
	3	0	2	0	0	0	2	3	6	0	9	2	0	
	4	1	43	14	0	9	32	9	25	0	32	32	12	
	5	0	62	50	0	13	17	1	6	0	25	33	19	
LST#10														37
	2	0	4	3	0	1	11	9	17	0	33	8	0	
	3	0	1	1	0	0	3	6	5	0	10	3	0	
	4	0	55	23	0	7	37	16	25	0	32	41	15	
	5	1	50	49	0	12	19	1	10	0	24	41	15	
LST#13														42
	2	0	9	6	0	1	14	16	22	0	38	12	2	
	3	0	7	1	0	0	7	6	3	0	9	6	1	
	4	1	44	19	0	8	31	5	24	0	27	36	11	
	5	0	61	48	0	9	16	3	9	1	25	39	14	
LST#16														53
	2	0	8	3	0	1	6	14	15	0	35	6	0	
	3	0	10	3	0	1	3	2	7	0	15	4	1	
	4	1	51	20	0	7	32	10	23	0	27	48	7	
	5	0	41	38	0	7	12	1	7	2	25	29	8	
LST#19														49
	2	0	11	6	0	4	11	12	24	0	33	16	1	
	3	1	4	1	0	0	3	6	4	0	9	5	0	
	4	0	40	16	0	10	37	9	23	0	19	25	22	
	5	0	47	32	0	11	13	0	16	2	26	27	13	
LST#22														45
	2	0	8	4	0	2	9	21	18	0	37	11	1	
	3	0	2	2	0	3	10	4	12	0	10	10	1	
	4	0	38	14	0	7	28	4	14	1	22	27	7	
	5	0	43	34	0	14	17	0	17	0	24	39	9	

MONTH 1 REGION 30

LST#	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													154
2	1	5	0	0	1	5	22	4	0	30	4	0	
3	0	5	0	0	1	4	5	5	0	14	3	0	
4	0	2	0	0	0	12	5	14	0	21	6	0	
5	1	19	3	0	1	7	0	24	1	34	11	0	
LST# 4													152
2	1	3	0	0	0	3	21	7	0	31	2	0	
3	0	1	0	0	0	6	9	7	0	15	4	0	
4	1	9	1	0	0	8	8	12	0	24	6	1	
5	1	11	4	0	4	8	0	23	1	32	10	0	
LST# 7													114
2	2	13	0	0	0	6	36	3	0	38	11	0	
3	1	4	0	0	0	6	7	2	0	6	7	0	
4	0	8	1	0	0	18	26	19	0	29	20	1	
5	4	19	4	0	6	16	4	30	1	25	22	5	
LST#10													102
2	3	6	0	0	0	9	40	2	0	38	11	0	
3	1	3	0	0	0	2	7	2	0	7	8	0	
4	8	11	0	0	0	18	33	18	0	34	21	4	
5	2	19	5	0	7	19	6	35	2	21	26	7	
LST#13													99
2	8	4	0	0	0	7	33	2	0	35	8	1	
3	5	4	0	0	0	2	12	5	0	16	3	2	
4	10	8	0	0	0	25	45	12	0	35	22	7	
5	4	19	2	0	4	13	6	32	1	26	18	6	
LST#16													100
2	4	2	0	0	0	7	26	2	0	27	7	0	
3	7	0	0	0	0	5	11	2	0	15	5	0	
4	10	15	0	0	1	22	30	20	0	37	23	5	
5	7	15	2	0	3	19	10	32	1	32	21	5	
LST#19													121
2	3	5	0	0	0	8	23	5	0	36	4	0	
3	0	2	0	0	0	2	15	4	0	17	3	0	
4	2	11	0	0	0	16	19	17	0	40	11	1	
5	0	17	5	0	5	13	0	27	0	26	19	1	
LST#22													104
2	0	5	0	0	0	8	26	3	0	40	1	0	
3	1	1	0	0	0	3	4	5	0	10	2	0	
4	0	7	3	0	1	10	9	15	0	21	6	2	
5	0	19	3	0	1	15	2	24	0	32	13	2	

MONTH [illegible] REGION 30

LST#	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													141
2	2	8	1	0	0	4	10	5	0	22	4	0	
3	0	4	0	0	1	4	5	3	0	11	3	0	
4	0	15	0	0	0	16	6	17	0	20	10	3	
5	0	25	2	0	4	11	1	17	0	25	10	5	
LST# 4													137
2	4	3	0	0	0	5	20	1	0	29	2	0	
3	0	9	0	0	1	3	5	3	0	10	4	1	
4	0	9	0	0	0	10	5	10	0	20	7	0	
5	0	22	2	0	6	13	0	20	3	25	16	3	
LST# 7													99
2	7	8	0	0	0	11	19	3	0	18	12	2	
3	2	6	0	0	0	6	10	2	0	8	3	4	
4	3	20	2	0	4	20	20	17	0	19	17	11	
5	1	29	3	0	5	26	10	35	1	22	29	10	
LST#10													94
2	15	5	0	0	0	7	28	2	0	22	11	4	
3	4	5	0	0	0	5	7	2	0	5	6	2	
4	13	13	0	0	1	25	28	15	0	19	18	13	
5	8	26	6	1	3	21	9	33	1	24	25	11	
LST#13													87
2	13	5	0	0	0	5	27	1	0	26	11	1	
3	4	2	0	0	0	4	8	1	0	7	3	2	
4	29	14	0	0	0	14	30	11	0	18	22	12	
5	10	20	3	0	4	26	10	39	2	23	35	7	
LST#16													73
2	18	4	0	2	0	9	27	4	0	23	16	3	
3	4	1	1	1	0	0	9	0	0	9	2	1	
4	23	18	1	3	0	20	33	14	0	27	23	13	
5	10	20	1	2	4	30	10	36	0	24	30	9	
LST#19													86
2	3	13	0	1	0	6	24	3	0	38	6	0	
3	3	2	0	0	1	4	10	3	0	11	6	0	
4	8	17	0	0	0	12	20	19	0	31	15	5	
5	4	28	1	0	8	25	7	23	0	19	25	9	
LST#22													120
2	2	8	0	1	1	3	20	5	0	34	3	0	
3	3	2	0	0	1	2	8	5	0	17	2	0	
4	0	10	0	0	0	10	7	11	0	14	9	2	
5	0	32	0	1	3	21	4	21	2	26	21	5	

MONTH 3 REGION 30

LST#	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													138
2	3	8	0	0	1	6	18	4	0	38	1	0	
3	0	4	0	0	0	6	11	5	0	16	5	0	
4	4	13	0	1	3	12	15	9	0	27	12	2	
5	2	19	2	0	4	10	5	15	0	26	11	3	
LST# 4													132
2	3	5	0	0	0	8	29	7	0	38	7	0	
3	0	3	0	0	0	4	8	3	0	9	3	1	
4	4	13	1	0	1	16	12	11	0	26	16	0	
5	0	17	1	0	5	14	2	22	1	31	14	1	
LST# 7													97
2	9	8	0	0	0	9	24	8	0	36	8	2	
3	4	7	0	0	0	6	12	2	0	12	5	3	
4	5	12	0	0	1	28	33	13	0	28	23	6	
5	3	22	0	0	6	29	10	35	1	21	27	10	
LST#10													104
2	14	6	0	1	0	9	29	2	0	27	11	4	
3	7	2	0	0	0	8	13	5	0	10	11	1	
4	30	10	0	0	0	23	24	14	0	15	21	14	
5	4	17	1	0	3	20	12	39	1	28	27	5	
LST#13													80
2	24	1	0	2	0	3	30	3	0	35	11	2	
3	11	0	0	0	0	4	10	3	0	7	6	3	
4	30	7	0	3	0	33	40	15	0	27	34	11	
5	19	14	1	0	4	22	8	39	1	27	25	10	
LST#16													76
2	17	3	0	2	0	3	19	2	0	23	10	1	
3	20	0	0	2	0	5	18	1	0	17	13	1	
4	34	8	0	3	0	26	44	19	0	31	29	15	
5	12	16	3	3	3	22	13	38	0	27	27	9	
LST#19													99
2	13	7	0	0	0	12	28	5	0	42	10	1	
3	6	8	0	2	0	3	9	3	0	13	9	0	
4	13	9	0	3	2	17	25	19	0	30	20	6	
5	6	12	1	0	3	22	5	28	2	22	21	5	
LST#22													135
2	4	7	0	0	0	8	20	7	0	36	5	0	
3	8	5	0	0	1	13	11	4	0	18	9	2	
4	6	15	0	0	3	10	11	11	0	23	15	1	
5	4	13	2	0	4	8	3	15	1	18	13	2	

MONTH 4 REGION 30

LST#	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													153
2	2	5	0	0	0	3	23	2	0	31	2	0	
3	0	5	0	0	1	2	2	1	0	7	2	0	
4	1	10	0	0	2	14	8	9	0	26	6	2	
5	2	15	2	2	6	16	1	20	1	22	14	5	
LST# 4													104
2	1	8	0	0	0	6	20	3	0	28	5	0	
3	1	2	0	0	1	3	4	3	0	8	3	0	
4	1	8	0	0	2	13	12	13	0	22	12	1	
5	2	13	3	0	4	15	3	25	4	29	14	4	
LST# 7													115
2	7	6	0	0	0	13	31	4	0	30	11	3	
3	2	1	0	0	0	4	14	1	0	9	5	1	
4	4	11	0	0	0	29	23	16	0	21	20	7	
5	5	8	4	0	6	23	7	30	3	18	23	7	
LST#10													113
2	25	1	0	0	0	6	31	2	0	32	15	1	
3	4	2	0	0	0	0	10	0	0	6	5	0	
4	19	6	0	1	0	21	29	14	0	19	21	9	
5	9	12	3	1	3	19	6	31	4	18	23	8	
LST#13													94
2	29	1	0	1	0	5	32	4	0	36	15	2	
3	12	0	0	1	0	5	10	1	0	7	8	2	
4	19	1	0	3	0	15	32	12	0	27	23	3	
5	18	9	3	3	1	24	15	26	5	15	26	12	
LST#16													85
2	21	1	0	2	0	5	27	2	0	36	11	0	
3	9	1	0	1	0	4	16	1	0	12	10	0	
4	25	8	0	5	0	17	40	10	0	26	24	10	
5	19	11	3	3	3	26	14	30	3	16	25	15	
LST#19													103
2	8	9	0	2	0	8	33	5	0	38	12	1	
3	4	1	0	0	0	4	12	1	0	12	5	0	
4	15	6	1	3	0	27	29	27	0	22	26	8	
5	3	18	1	2	0	11	6	16	1	15	11	7	
LST#22													133
2	1	10	0	0	0	4	24	8	0	45	4	0	
3	3	3	0	1	0	4	15	1	1	16	4	1	
4	1	6	0	0	0	15	8	14	0	19	10	2	
5	5	16	2	0	3	13	1	19	3	20	15	4	

MONTH 5 REGION 30

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													175
2	1	7	0	0	0	3	22	6	0	35	2	0	
3	0	1	0	0	0	6	6	4	0	11	3	0	
4	1	7	0	0	0	11	9	8	0	20	8	0	
5	0	4	0	0	1	7	2	19	0	17	8	0	
LST# 4													143
2	0	5	0	0	1	11	33	5	0	39	8	0	
3	0	1	0	0	1	5	7	2	0	8	4	0	
4	2	13	0	0	1	16	24	19	0	31	19	2	
5	0	7	0	1	0	8	3	15	0	15	8	1	
LST# 7													144
2	5	1	0	0	0	8	27	1	0	23	8	1	
3	4	2	0	0	0	6	17	0	0	9	7	2	
4	8	12	0	0	1	32	41	12	0	25	31	6	
5	1	2	0	0	1	11	7	13	1	10	10	2	
LST#10													131
2	23	3	0	2	0	11	31	4	0	31	14	5	
3	8	1	0	3	0	9	18	1	0	7	12	3	
4	14	3	0	3	0	16	29	9	0	20	16	7	
5	11	5	0	0	0	21	11	18	1	9	13	10	
LST#13													110
2	36	2	0	3	0	4	25	1	0	38	12	3	
3	11	4	0	2	0	3	10	2	0	11	9	1	
4	31	1	0	5	0	12	38	13	0	24	29	6	
5	18	3	0	4	3	16	15	18	0	7	18	11	
LST#16													110
2	26	4	0	2	0	6	23	2	0	31	13	2	
3	14	1	0	4	0	5	14	3	0	9	10	4	
4	41	1	0	9	1	16	49	9	0	23	39	8	
5	10	1	1	1	3	12	11	17	0	8	18	4	
LST#19													119
2	22	9	0	3	0	8	33	3	0	45	15	1	
3	4	4	0	0	0	7	18	1	0	13	9	1	
4	10	7	0	7	1	14	29	9	0	21	22	4	
5	7	4	1	1	3	14	3	22	0	9	14	6	
LST#22													161
2	4	13	0	0	0	3	24	4	0	44	2	0	
3	2	4	0	0	0	1	9	5	0	17	2	0	
4	5	2	0	0	1	6	12	8	0	16	9	0	
5	3	6	0	1	3	17	1	15	0	11	16	1	

MONTH 6 REGION 30

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													273
2	0	2	0	0	0	11	8	2	0	23	0	0	
3	0	1	0	0	0	3	4	0	0	4	2	0	
4	3	8	0	0	0	11	8	4	0	16	9	0	
5	2	1	0	0	0	7	2	10	0	5	7	1	
LST# 4													182
2	5	7	0	0	0	17	19	0	0	24	12	0	
3	1	0	0	0	0	5	4	0	0	10	0	0	
4	1	7	0	1	0	17	15	4	0	14	14	1	
5	1	0	0	0	0	6	1	10	0	8	5	0	
LST# 7													186
2	13	2	0	2	0	14	19	0	0	20	12	2	
3	1	0	0	0	0	3	3	0	0	5	1	0	
4	6	4	0	6	0	16	21	4	0	16	8	8	
5	1	4	0	0	0	7	0	6	0	6	3	2	
LST#10													173
2	23	2	0	2	0	11	17	0	0	18	14	3	
3	10	0	0	2	0	7	8	1	0	1	7	4	
4	12	3	0	6	0	25	24	6	0	11	14	12	
5	5	0	0	1	1	6	3	8	0	5	5	3	
LST#13													105
2	24	0	0	5	0	1	21	0	0	26	11	1	
3	8	1	0	4	0	5	6	1	0	7	5	2	
4	28	0	0	17	0	21	41	3	0	21	32	8	
5	2	0	0	3	0	4	3	8	0	6	4	2	
LST#16													100
2	25	4	0	6	0	6	26	0	0	21	20	2	
3	15	2	0	5	0	8	9	0	0	10	10	3	
4	22	0	0	15	0	12	31	10	0	14	32	4	
5	5	0	0	3	1	5	3	6	0	5	9	0	
LST#19													156
2	13	5	0	3	0	11	20	1	0	23	12	2	
3	3	3	0	3	0	6	10	1	0	9	4	3	
4	8	9	0	14	0	12	27	6	0	12	26	4	
5	4	2	0	5	0	7	3	11	0	5	12	1	
LST#22													183
2	7	6	0	1	0	7	11	2	0	32	4	0	
3	2	7	0	0	0	4	8	2	0	9	7	0	
4	3	8	0	1	0	9	9	9	0	15	9	2	
5	2	3	0	1	0	2	1	6	0	3	6	0	

MONTH 7 REGION 30

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													178
2	0	8	0	1	0	8	13	4	0	26	4	0	
3	2	4	0	2	0	6	6	1	0	11	5	0	
4	1	6	0	4	1	12	7	7	0	20	9	0	
5	2	10	0	3	0	9	1	12	0	14	10	1	
LST# 4													162
2	2	9	0	0	0	21	12	4	0	32	8	0	
3	1	4	0	3	0	13	9	0	0	8	8	2	
4	4	9	0	2	2	27	23	7	0	15	19	7	
5	4	4	0	2	0	8	1	7	0	11	6	1	
LST# 7													151
2	12	3	0	0	0	27	28	2	0	20	17	6	
3	7	2	0	1	0	17	13	1	0	6	13	3	
4	20	3	0	0	0	33	28	7	0	15	23	10	
5	2	3	0	1	0	9	1	8	0	7	7	1	
LST#10													153
2	24	0	0	6	0	19	22	0	0	15	25	2	
3	9	0	0	1	0	9	19	0	0	6	10	4	
4	27	2	0	3	0	31	29	6	0	10	20	16	
5	10	2	1	4	1	11	6	7	0	3	8	7	
LST#13													117
2	28	0	0	22	0	10	23	0	0	35	21	2	
3	10	1	0	7	0	7	13	0	0	9	7	5	
4	23	3	0	33	0	31	51	6	0	19	37	18	
5	3	3	0	5	0	4	1	4	0	1	5	3	
LST#16													119
2	26	1	0	17	0	12	24	0	0	27	22	3	
3	14	2	0	7	0	9	11	1	0	10	11	4	
4	18	0	0	37	0	25	55	2	0	7	44	14	
5	8	1	0	11	0	7	6	4	0	2	10	5	
LST#19													137
2	17	4	0	13	0	14	23	0	0	25	20	2	
3	3	1	0	6	0	6	13	0	0	3	10	2	
4	21	9	0	25	0	29	46	5	0	11	35	18	
5	0	6	1	7	0	8	9	6	0	0	11	5	
LST#22													168
2	4	11	0	3	0	21	16	2	0	30	12	1	
3	0	2	0	0	0	4	5	0	0	3	4	0	
4	2	15	0	9	0	18	19	8	0	18	17	5	
5	2	7	0	5	1	5	4	6	0	12	9	0	

MONTH 8 REGION 30

	CU	SC	ST	CB	AS	AC	CI	CS	NS	1	2	3	
LST# 1													190
2	2	5	0	3	0	23	11	1	0	31	7	0	
3	1	3	0	0	0	6	4	2	0	10	3	0	
4	2	5	0	7	0	17	8	4	0	14	13	1	
5	3	8	0	2	0	10	2	6	0	10	9	1	
LST# 4													173
2	2	3	0	1	0	24	12	0	0	29	5	1	
3	0	2	0	1	0	10	5	2	0	14	3	0	
4	2	11	0	6	0	24	12	2	0	25	10	4	
5	1	7	0	3	1	6	1	3	0	9	5	1	
LST# 7													165
2	23	3	0	4	0	34	30	0	0	32	19	8	
3	2	3	0	1	0	10	8	1	0	3	8	2	
4	17	7	0	4	0	36	26	2	0	11	21	13	
5	2	7	1	4	1	11	4	7	0	3	8	6	
LST#10													148
2	32	2	0	13	0	27	28	0	0	20	24	11	
3	6	0	0	2	0	7	6	1	0	4	3	4	
4	32	5	0	8	0	34	27	5	0	6	25	18	
5	6	6	1	3	0	10	6	5	0	3	4	8	
LST#13													101
2	46	0	0	26	0	16	25	0	0	44	27	5	
3	12	1	0	13	0	15	20	0	0	6	15	8	
4	22	5	0	37	0	24	40	6	0	12	27	22	
5	7	1	0	5	0	1	4	5	0	3	7	2	
LST#16													105
2	40	1	0	30	0	11	33	0	0	39	35	2	
3	12	1	0	18	0	8	20	2	0	7	15	8	
4	18	2	0	37	0	29	45	4	0	4	28	25	
5	1	1	0	10	0	4	3	2	0	3	6	2	
LST#19													132
2	22	12	0	16	0	15	33	1	0	36	24	5	
3	4	3	0	11	0	9	19	1	0	2	15	5	
4	12	6	0	18	0	19	24	5	0	1	20	16	
5	5	4	0	15	0	17	8	7	0	1	8	13	
LST#22													173
2	8	9	0	5	0	12	19	0	0	29	12	0	
3	2	4	0	6	0	8	6	2	0	2	7	4	
4	2	5	0	10	0	16	8	6	0	17	9	4	
5	2	6	0	7	1	15	5	5	0	5	15	2	

MONTH 9 REGION 30

	CU	SC	ST	CH	AS	AC	CI	CS	NS	1	2	3	
LST# 1													196
2	2	2	0	2	0	8	11	0	0	17	4	0	
3	1	2	0	1	0	6	6	1	0	13	2	0	
4	1	7	0	3	0	14	5	5	0	10	11	1	
5	2	9	0	2	2	9	1	2	1	5	10	1	
LST# 4													196
2	2	3	0	1	0	14	9	0	0	21	4	0	
3	0	6	0	1	0	4	4	3	0	14	2	0	
4	0	8	0	2	0	13	6	3	0	15	7	1	
5	2	4	1	1	1	5	0	1	1	2	7	0	
LST# 7													174
2	10	4	0	1	0	17	14	0	0	31	6	1	
3	5	1	0	0	0	8	7	0	0	7	4	2	
4	9	5	1	3	1	19	17	4	0	12	13	7	
5	2	5	1	1	0	10	2	4	0	3	8	2	
LST#10													178
2	24	0	0	0	0	11	20	3	0	20	10	6	
3	7	3	0	1	0	7	7	2	0	5	5	4	
4	14	4	0	4	0	16	17	4	0	9	14	7	
5	5	5	0	0	0	6	2	4	0	4	6	2	
LST#13													148
2	34	0	0	16	0	7	18	1	0	35	19	1	
3	9	0	0	2	0	4	10	1	0	4	5	4	
4	27	2	0	9	1	12	23	5	0	12	23	7	
5	5	3	1	2	0	7	2	5	1	2	6	4	
LST#16													150
2	25	2	0	13	0	2	15	0	0	31	10	2	
3	11	0	0	4	0	5	8	0	0	6	8	2	
4	24	1	0	13	0	25	30	8	0	13	26	12	
5	2	2	2	6	0	5	3	6	0	0	4	6	
LST#19													173
2	14	7	0	6	0	5	20	0	0	28	12	0	
3	4	1	0	8	0	4	10	0	0	5	8	2	
4	4	6	0	7	0	13	12	9	0	15	9	6	
5	3	3	0	5	0	4	0	7	0	3	6	2	
LST#22													189
2	6	5	0	4	0	7	12	2	0	28	4	0	
3	2	3	0	2	0	4	6	1	0	6	3	2	
4	5	6	0	4	0	10	8	4	0	8	13	1	
5	2	5	0	4	0	8	1	4	0	8	8	0	

MONTH 10 REGION 30

	CU	SC	ST	CH	AS	AC	CI	CS	NS	1	2	3	
LST# 1													193
2	1	4	0	0	0	3	11	1	0	20	0	0	
3	0	5	0	1	0	3	6	5	0	12	4	0	
4	0	6	0	0	0	5	5	7	0	19	2	0	
5	1	16	0	0	2	11	1	14	1	13	13	2	
LST# 4													189
2	0	9	0	0	0	8	11	2	0	28	1	0	
3	0	0	0	0	0	1	4	1	0	4	1	0	
4	2	9	1	0	0	12	12	11	0	22	11	1	
5	0	14	0	1	0	10	1	8	1	11	10	1	
LST# 7													156
2	3	2	0	0	0	12	33	2	0	35	7	1	
3	0	3	0	0	0	4	5	1	0	5	4	0	
4	9	14	2	2	0	19	19	12	0	16	23	5	
5	0	19	0	0	0	12	5	13	0	7	18	2	
LST#10													161
2	7	3	0	0	0	8	31	1	0	26	9	2	
3	2	3	0	0	0	5	12	1	0	8	3	3	
4	8	10	1	0	0	13	22	7	0	15	20	2	
5	7	15	1	1	1	11	3	14	0	11	12	6	
LST#13													146
2	24	1	0	0	0	11	27	3	0	25	19	1	
3	6	1	0	1	0	6	9	3	0	8	9	0	
4	19	7	0	1	1	10	33	7	0	20	17	8	
5	4	14	2	0	1	8	4	12	1	8	10	6	
LST#16													141
2	23	2	0	0	0	5	29	1	0	23	14	3	
3	3	0	0	1	0	5	11	0	0	8	3	2	
4	15	13	0	4	1	20	34	12	0	25	19	12	
5	3	9	1	1	2	10	7	14	0	14	13	2	
LST#19													164
2	4	5	0	1	0	5	19	1	0	27	4	0	
3	0	2	0	0	0	3	9	2	0	12	2	0	
4	3	8	0	0	0	14	18	18	0	27	17	0	
5	4	13	0	1	3	5	1	10	0	18	5	3	
LST#22													178
2	1	5	0	0	0	7	23	2	0	30	4	0	
3	1	3	0	1	0	4	5	6	0	14	3	0	
4	0	10	0	0	0	12	7	13	0	24	9	0	
5	4	11	0	2	1	1	1	6	2	9	6	2	

MONTH 11 REGION 30

	CU	SC	ST	CH	AS	AC	CI	CS	NS	1	2	3	
LST# 1													152
2	2	1	0	0	0	15	19	3	0	32	4	0	
3	0	3	0	0	0	2	9	4	0	14	2	0	
4	1	9	0	0	1	9	6	14	0	24	8	0	
5	0	10	9	0	3	13	0	15	0	15	13	3	
LST# 4													149
2	0	5	1	0	0	5	18	2	0	29	1	0	
3	0	2	0	0	1	8	7	3	0	15	3	0	
4	1	6	2	0	0	14	9	9	0	21	7	2	
5	0	23	6	1	4	9	2	19	2	21	16	4	
LST# 7													118
2	3	5	0	0	0	11	23	2	0	25	8	1	
3	1	5	1	0	0	5	8	2	0	8	4	2	
4	2	12	2	0	2	31	27	17	0	20	21	10	
5	3	23	6	0	4	24	6	27	2	20	24	9	
LST#10													119
2	5	2	0	0	0	9	23	1	0	20	5	3	
3	5	3	0	0	0	3	6	3	0	7	2	3	
4	11	21	0	0	0	21	34	16	0	28	20	11	
5	3	24	3	0	5	26	8	26	2	16	25	10	
LST#13													106
2	7	2	0	0	0	6	26	1	0	25	7	1	
3	13	5	0	0	1	11	14	3	0	8	12	5	
4	14	6	0	0	0	19	28	15	0	22	24	4	
5	5	18	9	0	3	22	7	32	2	23	24	8	
LST#16													106
2	8	2	0	0	0	8	25	1	0	26	6	2	
3	5	3	0	0	0	4	11	2	0	13	3	2	
4	11	12	0	0	3	24	32	12	0	21	23	9	
5	6	16	10	0	4	25	10	28	2	25	24	9	
LST#19													118
2	1	9	0	0	0	5	33	1	0	41	4	0	
3	2	0	0	0	0	3	11	2	0	12	3	0	
4	4	12	0	1	1	14	13	13	0	23	11	4	
5	5	15	4	1	4	22	5	26	3	28	21	5	
LST#22													136
2	1	7	0	1	0	8	32	6	0	49	3	0	
3	1	1	0	0	0	4	4	1	0	4	2	1	
4	1	9	1	0	0	12	11	9	0	25	9	0	
5	1	12	9	1	2	17	1	21	1	20	16	4	

MONTH 12 REGION 30

	CU	SC	ST	CH	AS	AC	CI	CS	NS	1	2	3	
LST# 1													171
2	0	6	0	0	0	3	19	2	0	26	2	0	
3	2	8	0	0	1	4	3	4	0	16	3	0	
4	1	4	0	0	0	5	7	8	0	14	4	1	
5	0	29	6	0	1	9	0	12	2	29	7	5	
LST# 4													171
2	0	2	0	0	0	2	15	5	0	24	0	0	
3	0	1	0	0	0	2	5	2	0	8	1	0	
4	1	12	1	0	1	8	9	5	0	21	8	0	
5	0	32	6	0	3	6	3	17	4	27	11	7	
LST# 7													115
2	1	8	0	0	0	11	27	4	0	35	8	0	
3	1	6	0	1	0	3	12	2	0	11	4	2	
4	0	19	1	0	0	18	31	15	0	28	23	3	
5	3	37	4	0	0	19	6	22	2	18	20	11	
LST#10													107
2	2	3	0	0	0	5	29	3	0	30	6	0	
3	1	2	0	1	0	6	9	0	0	9	2	2	
4	8	22	0	0	0	23	40	11	0	34	18	11	
5	2	40	10	0	3	18	15	26	1	23	22	15	
LST#13													99
2	11	4	0	0	0	8	34	1	0	34	12	0	
3	4	6	1	1	0	5	11	1	0	10	5	3	
4	8	12	0	0	0	18	38	10	0	32	16	7	
5	1	39	5	0	3	21	10	31	0	27	15	17	
LST#16													98
2	10	6	0	1	0	4	29	1	0	33	9	0	
3	1	4	0	1	0	6	12	1	0	7	6	2	
4	7	9	0	1	0	19	38	15	0	37	20	4	
5	3	34	4	1	3	25	12	33	0	26	21	15	
LST#19													130
2	2	8	0	1	0	6	29	7	0	42	4	1	
3	3	4	0	0	0	2	7	3	0	11	4	0	
4	1	15	1	0	1	10	13	15	0	30	13	0	
5	1	32	3	0	4	13	4	15	0	22	16	6	
LST#22													167
2	1	7	0	0	0	2	19	4	0	23	8	0	
3	1	4	0	0	0	1	3	4	0	7	3	0	
4	1	15	1	0	2	12	7	13	0	22	13	1	
5	0	30	4	0	6	6	1	9	1	21	7	7	

CLOUD COVER STATISTICS

CLIMATOLOGICAL REGION NUMBER 30 STATISTICS FOR MONTH 1

	UNCONDITIONAL PROBABILITIES TIME (LST)									CONDITIONAL PROBABILITIES 24 HOUR TEMPORAL							200 NM SPATIAL				
	01	04	07	10	13	16	19	22			1	2	3	4	5			1	2	3	4	5
1	.55	.54	.40	.36	.36	.36	.43	.52		1	.51	.18	.08	.18	.05		1	.34	.46	.01	.19	.0
2	.13	.12	.18	.17	.15	.13	.15	.14	G	2	.44	.27	.18	.07	.04	G	2	.76	.03	.0	.01	.20
3	.06	.07	.05	.05	.08	.07	.07	.05	I V	3	.36	.34	.0	.20	.10	I V	3	.23	.02	.23	.40	.12
4	.10	.12	.18	.22	.22	.22	.19	.13	E N	4	.26	.11	.11	.35	.17	E N	4	.24	.02	.24	.40	.10
5	.16	.15	.19	.20	.19	.22	.16	.16		5	.16	.17	.05	.45	.17		5	.34	.03	.16	.29	.18

CLIMATOLOGICAL REGION NUMBER 30 STATISTICS FOR MONTH 2

	UNCONDITIONAL PROBABILITIES TIME (LST)									CONDITIONAL PROBABILITIES 24 HOUR TEMPORAL							200 NM SPATIAL				
	01	04	07	10	13	16	19	22			1	2	3	4	5			1	2	3	4	5
1	.56	.55	.41	.38	.35	.29	.36	.48		1	.49	.18	.08	.19	.06		1	.33	.46	.01	.19	.01
2	.11	.14	.13	.15	.15	.16	.16	.16	G	2	.42	.27	.18	.08	.05	G	2	.73	.03	.0	.01	.23
3	.06	.05	.06	.06	.05	.06	.08	.07	I V	3	.36	.33	.0	.20	.11	I V	3	.22	.02	.21	.41	.14
4	.12	.10	.18	.18	.20	.25	.20	.10	E N	4	.25	.10	.10	.36	.19	E N	4	.23	.02	.22	.41	.12
5	.15	.16	.22	.23	.25	.24	.20	.19		5	.15	.16	.04	.45	.20		5	.31	.03	.15	.30	.21

CLIMATOLOGICAL REGION NUMBER 30 STATISTICS FOR MONTH 3

	UNCONDITIONAL PROBABILITIES TIME (LST)									CONDITIONAL PROBABILITIES 24 HOUR TEMPORAL							200 NM SPATIAL				
	01	04	07	10	13	16	19	22			1	2	3	4	5			1	2	3	4	5
1	.48	.46	.35	.37	.28	.26	.35	.47		1	.47	.19	.08	.20	.06		1	.28	.52	.01	.19	.0
2	.14	.16	.16	.16	.17	.13	.19	.16	G	2	.40	.28	.19	.08	.05	G	2	.71	.04	.0	.01	.24
3	.08	.05	.07	.07	.06	.10	.08	.11	I V	3	.33	.35	.0	.21	.11	I V	3	.20	.03	.22	.42	.13
4	.15	.16	.21	.17	.26	.27	.21	.14	E N	4	.23	.10	.10	.39	.18	E N	4	.21	.02	.22	.44	.11
5	.15	.17	.21	.23	.23	.24	.17	.12		5	.14	.16	.05	.46	.19		5	.30	.03	.15	.32	.20

CLOUD COVER STATISTICS

CLIMATOLOGICAL REGION NUMBER 30 STATISTICS FOR MONTH 4

	UNCONDITIONAL PROBABILITIES TIME (LST)									CONDITIONAL PROBABILITIES 24 HOUR TEMPORAL						200 NM SPATIAL				
	01	04	07	10	13	16	19	22		1	2	3	4	5		1	2	3	4	5
1	.56	.53	.44	.43	.36	.31	.39	.50	1	.46	.18	.13	.13	.10	1	.72	.13	.14	.01	.0
2	.14	.13	.17	.17	.19	.18	.18	.18	G 2	.34	.17	.09	.16	.24	G 2	.21	.72	.0	.05	.02
3	.04	.06	.05	.04	.06	.08	.07	.08	I V 3	.17	.25	.23	.34	.01	I V 3	.68	.0	.32	.0	.0
4	.12	.12	.17	.18	.20	.22	.24	.10	E N 4	.48	.25	.01	.25	.01	E N 4	.01	.02	.02	.94	.01
5	.14	.16	.17	.18	.19	.21	.12	.14	5	.29	.15	.0	.55	.01	5	.01	.02	.02	.01	.94

CLIMATOLOGICAL REGION NUMBER 30 STATISTICS FOR MONTH 5

	UNCONDITIONAL PROBABILITIES TIME (LST)									CONDITIONAL PROBABILITIES 24 HOUR TEMPORAL						200 NM SPATIAL				
	01	04	07	10	13	16	19	22		1	2	3	4	5		1	2	3	4	5
1	.62	.51	.52	.48	.38	.38	.40	.57	1	.47	.19	.13	.13	.08	1	.72	.13	.14	.01	.0
2	.13	.17	.12	.17	.20	.17	.24	.17	G 2	.36	.18	.09	.17	.20	G 2	.22	.71	.0	.05	.02
3	.05	.05	.06	.07	.07	.09	.08	.07	I V 3	.18	.25	.22	.34	.01	I V 3	.68	.0	.32	.0	.0
4	.11	.19	.22	.16	.21	.25	.17	.09	E N 4	.49	.25	.01	.24	.01	E N 4	.01	.02	.02	.94	.01
5	.09	.08	.08	.12	.14	.11	.11	.10	5	.30	.15	.0	.54	.01	5	.01	.02	.02	.01	.94

CLIMATOLOGICAL REGION NUMBER [illegible]0 STATISTICS FOR MONTH 6

	UNCONDITIONAL PROBABILITIES TIME (LST)									CONDITIONAL PROBABILITIES 24 HOUR TEMPORAL						200 NM SPATIAL				
	01	04	07	10	13	16	19	22		1	2	3	4	5		1	2	3	4	5
1	.74	.68	.70	.66	.55	.53	.59	.68	1	.54	.19	.11	.12	.04	1	.76	.11	.12	.01	.0
2	.09	.14	.12	.12	.14	.16	.14	.14	G 2	.46	.19	.09	.16	.10	G 2	.25	.70	.0	.04	.01
3	.03	.03	.03	.05	.05	.08	.06	.06	I V 3	.22	.26	.20	.32	.0	I V 3	.72	.0	.28	.0	.0
4	.09	.10	.11	.13	.22	.18	.15	.09	E N 4	.56	.24	.0	.20	.0	E N 4	.01	.02	.02	.94	.01
5	.05	.05	.04	.04	.04	.05	.06	.03	5	.36	.16	.0	.48	.0	5	.01	.03	.03	.02	.91

CLOUD COVER STATISTICS

CLIMATOLOGICAL REGION NUMBER 30 STATISTICS FOR MONTH 7

	UNCONDITIONAL PROBABILITIES TIME (LST)									CONDITIONAL PROBABILITIES 24 HOUR TEMPORAL							CONDITIONAL PROBABILITIES 200 NM SPATIAL				
	01	04	07	10	13	16	19	22			1	2	3	4	5			1	2	3	4	5
1	.62	.56	.52	.52	.40	.40	.48	.59		1	.50	.20	.13	.13	.04		1	.72	.13	.14	.01	.0
2	.11	.15	.16	.15	.21	.20	.17	.16	G	2	.41	.20	.10	.17	.12	G	2	.22	.72	.0	.05	.01
3	.06	.06	.08	.07	.08	.09	.05	.03	I V	3	.19	.27	.22	.32	.0	I V	3	.68	.0	.32	.0	.0
4	.12	.16	.18	.18	.27	.25	.25	.15	E N	4	.50	.26	.01	.22	.01	E N	4	.01	.02	.02	.94	.01
5	.09	.07	.06	.08	.04	.06	.05	.07		5	.31	.16	.0	.53	.0		5	.01	.03	.03	.02	.91

CLIMATOLOGICAL REGION NUMBER 30 STATISTICS FOR MONTH 8

	UNCONDITIONAL PROBABILITIES TIME (LST)									CONDITIONAL PROBABILITIES 24 HOUR TEMPORAL							CONDITIONAL PROBABILITIES 200 NM SPATIAL				
	01	04	07	10	13	16	19	22			1	2	3	4	5			1	2	3	4	5
1	.61	.62	.51	.52	.35	.35	.45	.60		1	.49	.21	.13	.13	.04		1	.72	.13	.14	.01	.0
2	.15	.13	.22	.20	.28	.27	.24	.15	G	2	.41	.21	.10	.17	.11	G	2	.22	.73	.0	.04	.01
3	.05	.07	.05	.05	.11	.13	.08	.05	I V	3	.19	.28	.21	.32	.0	I V	3	.67	.01	.32	.0	.0
4	.12	.13	.16	.18	.22	.21	.15	.12	E N	4	.49	.27	.01	.22	.01	E N	4	.01	.02	.02	.94	.01
5	.07	.05	.06	.05	.04	.04	.08	.08		5	.31	.17	.0	.52	.0		5	.01	.03	.03	.02	.91

CLIMATOLOGICAL REGION NUMBER 30 STATISTICS FOR MONTH 9

	UNCONDITIONAL PROBABILITIES TIME (LST)									CONDITIONAL PROBABILITIES 24 HOUR TEMPORAL							CONDITIONAL PROBABILITIES 200 NM SPATIAL				
	01	04	07	10	13	16	19	22			1	2	3	4	5			1	2	3	4	5
1	.69	.70	.62	.63	.53	.53	.62	.67		1	.56	.19	.11	.11	.03		1	.76	.11	.12	.01	.0
2	.10	.10	.16	.15	.22	.17	.16	.13	G	2	.48	.19	.08	.15	.10	G	2	.25	.70	.0	.04	.01
3	.06	.07	.04	.05	.05	.06	.05	.04	I V	3	.23	.27	.19	.31	.0	I V	3	.73	.0	.27	.0	.0
4	.08	.09	.12	.12	.15	.19	.11	.09	E N	4	.57	.24	.0	.19	.0	E N	4	.01	.02	.02	.94	.01
5	.07	.04	.06	.05	.05	.05	.06	.07		5	.37	.16	.0	.47	.0		5	.02	.03	.03	.02	.90

CLOUD COVER STATISTICS

CLIMATOLOGICAL REGION NUMBER 30 STATISTICS FOR MONTH 10

	UNCONDITIONAL PROBABILITIES TIME (LST) 01	04	07	10	13	16	19	22		CONDITIONAL PROBABILITIES 24 HOUR TEMPORAL 1	2	3	4	5		200 NM SPATIAL 1	2	3	4	5
1	.71	.69	.57	.58	.53	.52	.61	.66		1	.58	.17	.07	.15	.03		1	.45	.38	.01	.16	.0
2	.08	.10	.15	.14	.16	.14	.11	.12	G	2	.50	.26	.16	.06	.02	G	2	.86	.02	.0	.0	.12
3	.05	.02	.04	.05	.06	.04	.05	.06	I V	3	.43	.34	.0	.17	.06	I V	3	.30	.02	.28	.31	.09
4	.07	.12	.15	.13	.16	.20	.15	.11	F N	4	.34	.11	.11	.33	.11	E N	4	.30	.02	.28	.33	.07
5	.09	.07	.09	.10	.09	.10	.08	.05		5	.21	.19	.05	.42	.13		5	.42	.02	.19	.24	.13

CLIMATOLOGICAL REGION NUMBER 30 STATISTICS FOR MONTH 11

	UNCONDITIONAL PROBABILITIES TIME (LST) 01	04	07	10	13	16	19	22		CONDITIONAL PROBABILITIES 24 HOUR TEMPORAL 1	2	3	4	5		200 NM SPATIAL 1	2	3	4	5
1	.57	.57	.43	.44	.40	.39	.43	.49		1	.51	.18	.08	.18	.05		1	.36	.44	.01	.19	.0
2	.13	.11	.12	.11	.12	.12	.15	.20	G	2	.44	.27	.18	.07	.04	G	2	.76	.03	.0	.01	.20
3	.06	.06	.06	.04	.08	.06	.06	.03	I V	3	.37	.33	.0	.20	.10	I V	3	.24	.02	.23	.38	.13
4	.12	.12	.20	.23	.20	.21	.16	.13	E N	4	.27	.10	.10	.36	.17	E N	4	.25	.02	.24	.39	.10
5	.12	.14	.19	.18	.20	.22	.20	.15		5	.16	.16	.05	.45	.18		5	.35	.02	.16	.28	.19

CLIMATOLOGICAL REGION NUMBER 30 STATISTICS FOR MONTH 12

	UNCONDITIONAL PROBABILITIES TIME (LST) 01	04	07	10	13	16	19	22		CONDITIONAL PROBABILITIES 24 HOUR TEMPORAL 1	2	3	4	5		200 NM SPATIAL 1	2	3	4	5
1	.62	.63	.43	.40	.36	.36	.47	.61		1	.51	.18	.08	.18	.05		1	.34	.46	.01	.19	.0
2	.10	.08	.16	.13	.17	.15	.17	.09	G	2	.44	.27	.18	.07	.04	G	2	.75	.03	.0	.01	.21
3	.07	.03	.06	.05	.06	.06	.05	.04	I V	3	.36	.34	.0	.20	.10	I V	3	.23	.02	.22	.40	.13
4	.07	.10	.18	.21	.20	.21	.15	.14	E N	4	.26	.11	.10	.36	.17	E N	4	.24	.02	.23	.41	.10
5	.14	.16	.17	.21	.21	.22	.16	.12		5	.16	.16	.05	.45	.18		5	.33	.03	.16	.29	.19

APPENDIX B

TABLE B-1A

SPATIAL CONDITIONALS: KANSAS CITY, MISSOURI - COLUMBIA, MISSOURI

SPATIAL CONDITIONALS

ANCHOR STATION KANSAS CITY MISSOURI TO COLUMBIA MISSOURI

MONTH 1 YEAR 58 THRU 67

CT	CLR	CU	SC	ST	CU	AS	AC	CI	CS	NS	TOTAL
0	615	1	72	29	0	1	39	45	6	0	808
	0.76	0.00	0.09	0.04	0.0	0.00	0.05	0.06	0.01	0.0	
1	0	0	1	0	0	0	0	0	0	0	1
	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2	25	0	196	58	2	2	50	11	11	0	356
	0.07	0.0	0.55	0.16	0.01	0.01	0.14	0.03	0.03	0.0	
3	14	1	76	153	0	1	13	10	4	0	274
	0.05	0.00	0.28	0.56	0.0	0.00	0.05	0.04	0.01	0.0	
4	0	0	2	0	0	0	0	0	0	0	2
	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
5	4	0	9	2	0	1	22	7	14	0	59
	0.07	0.0	0.15	0.03	0.0	0.02	0.37	0.12	0.24	0.0	
6	35	0	33	9	0	5	93	27	18	0	218
	0.16	0.0	0.15	0.04	0.0	[illegible]	0.43	0.12	0.08	0.0	
7	96	0	27	6	0	0	24	99	18	0	270
	0.36	0.0	0.10	0.02	0.0	0.0	0.09	0.37	0.07	0.0	
8	52	0	13	6	0	5	24	102	[illegible]	0	266
	0.20	0.0	0.05	0.02	0.0	0.01	0.09	[illegible]	[illegible]	0.0	
9	0	0	5	7	0	2	1	0	0	0	15
	0.0	0.0	0.33	0.47	0.0	0.13	0.07	0.0	0.0	0.0	

TABLE B-1B

SPATIAL CONDITIONALS: KANSAS CITY, MISSOURI - COLUMBIA, MISSOURI

SPATIAL CONDITIONALS

ANCHOR STATION KANSAS CITY MISSOURI TO COLUMBIA MISSOURI

MONTH 7 YEAR 58 THRU 67

DIST (NM) = 102.72

CT	CLR	CU	SC	ST	CB	AS	AC	CI	CS	NS	TOTAL
CL	450	49	21	6	6	1	45	46	6	0	610
	0.70	0.08	0.03	0.01	0.01	0.00	0.07	0.08	0.01	0.0	
CU	30	109	29	3	5	0	28	33	7	0	244
	0.12	0.45	0.12	0.01	0.02	0.0	0.11	0.14	0.03	0.0	
SC	15	14	57	8	9	2	35	11	9	0	160
	0.09	0.09	0.36	0.05	0.06	0.01	0.22	0.07	0.06	0.0	
ST	0	1	14	13	0	0	13	2	3	0	46
	0.0	0.02	0.30	0.28	0.0	0.0	0.28	0.04	0.07	0.0	
CB	5	13	16	0	13	1	28	15	8	0	99
	0.05	0.13	0.16	0.0	0.13	0.01	0.28	0.15	0.08	0.0	
AS	0	1	3	1	0	1	12	1	4	0	23
	0.0	0.04	0.13	0.04	0.0	0.04	0.52	0.04	0.17	0.0	
AC	99	25	45	6	20	1	194	71	47	0	508
	0.19	0.05	0.09	0.01	0.04	0.00	0.38	0.14	0.09	0.0	
CI	132	44	29	4	14	0	74	198	49	0	544
	0.24	0.08	0.05	0.01	0.03	0.0	0.14	0.36	0.09	0.0	
CS	23	12	22	10	6	4	29	62	33	0	201
	0.11	0.06	0.11	0.05	0.03	0.02	0.14	0.31	0.16	0.0	
NS	0	0	3	1	0	0	1	0	0	0	5
	0.0	0.0	0.60	0.20	0.0	0.0	0.20	0.0	0.0	0.0	

TABLE B-2A

SPATIAL CONDITIONALS: KANSAS CITY, MISSOURI - BELLEVILLE, ILLINOIS

SPATIAL CONDITIONALS

ANCHOR STATION KANSAS CITY MISSOURI TO BELLEVILLE ILLINOIS

MONTH 1 YEAR 58 THRU 67

CT	CLR	CU	SC	ST	CB	AS	AC	CI	CS	NS	TOTAL	DIST (NM) = 224.99
CL	413 0.67	2 0.00	66 0.11	15 0.02	0 0.0	5 0.01	44 0.07	21 0.03	55 0.09	0 0.0	621	
CU	0 0.0	0 0.0	0 0.0	1 1.00	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1	
SC	31 0.15	0 0.0	96 0.48	29 0.14	0 0.0	2 0.01	21 0.10	3 0.01	10 0.05	8 0.04	200	
ST	16 0.08	0 0.0	68 0.33	77 0.37	0 0.0	5 0.02	15 0.07	0 0.0	13 0.06	14 0.07	208	
CB	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0	
AS	5 0.16	0 0.0	6 0.19	5 0.16	0 0.0	5 0.16	3 0.09	2 0.06	6 0.19	0 0.0	32	
AC	48 0.34	1 0.01	20 0.14	14 0.10	0 0.0	9 0.06	21 0.15	12 0.08	16 0.11	2 0.01	143	
CI	65 0.38	1 0.01	25 0.14	6 0.03	0 0.0	0 0.0	11 0.06	9 0.05	56 0.32	0 0.0	173	
CS	46 0.32	0 0.0	11 0.06	4 0.03	0 0.0	3 0.02	14 0.10	26 0.18	42 0.29	0 0.0	146	
NS	0 0.0	0 0.0	0 0.0	4 0.50	0 0.0	0 0.0	4 0.50	0 0.0	0 0.0	0 0.0	8	

TABLE B-2B

SPATIAL CONDITIONALS: KANSAS CITY, MISSOURI - BELLEVILLE, ILLINOIS

SPATIAL CONDITIONALS

ANCHOR STATION KANSAS CITY MISSOURI TO BELLEVILLE ILLINOIS

MONTH 7 YEAR 58 THRU 67

DIST (NM) = 224.9

CT	CLR	CU	SC	ST	CB	AS	AC	CI	CS	NS	TOTAL
CL	227 0.51	20 0.05	21 0.05	4 0.01	9 0.02	7 0.02	49 0.11	34 0.08	70 0.16	0 0.0	441
CU	10 0.06	41 0.26	12 0.08	2 0.01	9 0.06	3 0.02	25 0.16	15 0.10	38 0.25	0 0.0	155
SC	10 0.08	11 0.09	18 0.15	8 0.07	3 0.03	4 0.03	33 0.28	8 0.07	24 0.20	0 0.0	119
ST	0 0.0	0 0.0	3 0.08	3 0.08	1 0.03	1 0.03	9 0.25	4 0.11	15 0.42	0 0.0	36
CB	8 0.13	8 0.13	3 0.05	0 0.0	7 0.11	3 0.05	10 0.16	11 0.17	14 0.22	0 0.0	64
AS	1 0.06	1 0.06	2 0.13	0 0.0	1 0.06	0 0.0	0 0.0	1 0.06	10 0.63	0 0.0	16
AC	93 0.27	19 0.06	30 0.09	1 0.00	9 0.03	3 0.01	65 0.19	30 0.09	89 0.26	1 0.00	340
CI	95 0.28	32 0.09	21 0.06	0 0.0	7 0.02	6 0.02	41 0.12	31 0.09	111 0.32	1 0.00	345
CS	23 0.15	10 0.07	9 0.06	3 0.02	2 0.01	6 0.04	22 0.14	23 0.15	55 0.36	0 0.0	153
NS	0 0.0	0 0.0	2 0.67	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1 0.33	0 0.0	3

LE B-3A

SPATIAL CONDITIONALS: BE[illegible]ILLE, ILLINOIS - PEORIA, ILLINOIS

SPATIAL CONDITIONALS

ANCHOR STATION BELLEVILLE ILLINOIS TO PEORIA ILLINOIS

MONTH 1 YEAR 58 THRU 67

CT	CLR	CU	SC	ST	CB	AS	AC	CI	CS	NS	TOTAL
CL	437 0.68	1 0.00	50 0.08	10 0.02	0 0.0	2 0.00	49 0.08	82 0.13	12 0.02	0 0.0	643
CU	1 0.25	0 0.0	1 0.25	0 0.0	0 0.0	0 0.0	0 0.0	2 0.50	0 0.0	0 0.0	4
SC	32 0.11	0 0.0	150 0.52	57 0.20	0 0.0	8 0.03	19 0.07	14 0.05	7 0.02	3 0.01	290
ST	3 0.02	0 0.0	49 0.33	77 0.52	0 0.0	5 0.03	3 0.02	4 0.03	5 0.03	1 0.01	147
CB	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0
AS	1 0.04	0 0.0	4 0.14	2 0.07	0 0.0	2 0.07	6 0.21	6 0.21	7 0.25	0 0.0	28
AC	35 0.27	0 0.0	26 0.20	5 0.04	0 0.0	4 0.03	33 0.25	12 0.09	15 0.11	2 0.02	132
CI	25 0.34	0 0.0	3 0.04	1 0.01	0 0.0	1 0.01	6 0.08	27 0.37	10 0.14	0 0.0	73
CS	61 0.31	1 0.01	32 0.16	5 0.03	0 0.0	1 0.01	35 0.18	45 0.23	18 0.09	0 0.0	198
NS	0 0.0	0 0.0	7 0.28	13 0.52	0 0.0	1 0.04	3 0.12	1 0.04	0 0.0	0 0.0	25

DIST (NM) = 127.58

TABLE B-3B

SPATIAL CONDITIONALS: BELLEVILLE, ILLINOIS - PEORIA, ILLINOIS

SPATIAL CONDITIONALS

ANCHOR STATION BELLEVILLE ILLINOIS TO PEORIA ILLINOIS

MONTH 7 YEAR 58 THRU 67

DIST (NM) = 127.58

CT	CLR	CU	SC	ST	CB	AS	AC	CI	CS	NS	TOTAL
CL	296	17	12	2	6	0	47	85	5	0	470
	0.63	0.04	0.03	0.00	0.01	0.0	0.10	0.18	0.01	0.0	
CU	21	64	8	0	4	1	18	18	6	0	140
	0.15	0.46	0.06	0.0	0.03	0.01	0.13	0.13	0.04	0.0	
SC	22	22	22	7	1	2	26	14	3	0	119
	0.18	0.18	0.18	0.06	0.01	0.02	0.22	0.12	0.03	0.0	
ST	2	1	9	6	0	0	3	1	0	0	22
	0.09	0.05	0.41	0.27	0.0	0.0	0.14	0.05	0.0	0.0	
CB	9	6	13	2	3	0	7	6	2	0	48
	0.19	0.13	0.27	0.04	0.06	0.0	0.15	0.13	0.04	0.0	
AS	8	4	3	5	0	2	4	5	1	1	33
	0.24	0.12	0.09	0.15	0.0	0.06	0.12	0.15	0.03	0.03	
AC	37	28	51	11	5	2	72	33	16	0	255
	0.15	0.11	0.20	0.04	0.02	0.01	0.28	0.13	0.06	0.0	
CI	46	19	12	5	2	2	18	40	12	0	156
	0.29	0.12	0.08	0.03	0.01	0.01	0.12	0.26	0.08	0.0	
CS	90	47	36	15	9	5	85	94	45	0	426
	0.21	0.11	0.08	0.04	0.02	0.01	0.20	0.22	0.11	0.0	
NS	0	0	0	0	0	0	2	0	0	0	2
	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	

TABLE B-4A

SPATIAL CONDITIONALS: BELLEVILLE, ILLINOIS - CHICAGO, ILLINOIS

SPATIAL CONDITIONALS

ANCHOR STATION BELLEVILLE ILLINOIS TO CHICAGO, ILLINOIS

MONTH 1 YEAR 58 THRU 67

DIST (NM) = 216.29

CT	CLR	CU	SC	ST	CH	AS	AC	CI	CS	NS	TOTAL
CL	330 0.51	2 0.00	103 0.16	31 0.05	0 0.0	6 0.01	68 0.11	67 0.10	35 0.05	0 0.0	642
CU	1 0.25	0 0.0	1 0.25	0 0.0	0 0.0	0 0.0	0 0.0	2 0.50	0 0.0	0 0.0	4
SC	27 0.09	0 0.0	143 0.49	52 0.18	0 0.0	5 0.02	19 0.07	16 0.05	29 0.10	0 0.0	291
ST	3 0.02	0 0.0	60 0.38	70 0.45	0 0.0	6 0.04	12 0.08	4 0.03	2 0.01	0 0.0	157
CB	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0
AS	6 0.22	0 0.0	5 0.19	0 0.0	0 0.0	0 0.0	3 0.11	5 0.19	8 0.30	0 0.0	27
AC	33 0.25	0 0.0	38 0.29	6 0.05	0 0.0	8 0.06	25 0.19	12 0.09	11 0.08	0 0.0	133
CI	14 0.19	0 0.0	8 0.11	3 0.04	0 0.0	0 0.0	9 0.12	19 0.26	20 0.27	0 0.0	73
CS	50 0.26	0 0.0	48 0.24	11 0.06	0 0.0	9 0.05	25 0.13	23 0.12	30 0.15	0 0.0	196
NS	0 0.0	0 0.0	4 0.15	14 0.54	0 0.0	0 0.0	6 0.23	0 0.0	1 0.04	1 0.04	26

TABLE B-4B

SPATIAL CONDITIONALS: BELLEVILLE, ILLINOIS - CHICAGO, ILLINOIS

SPATIAL CONDITIONALS

ANCHOR STATION BELLEVILLE ILLINOIS TO CHICAGO, ILLINOIS

MONTH 7 YEAR 58 THRU 67

DIST (NM) = 216.29

CT	CLR	CU	SC	ST	CB	AS	AC	CI	CS	NS	TOTAL
CL	242 0.52	30 0.06	27 0.06	7 0.02	8 0.02	2 0.00	64 0.14	63 0.14	19 0.04	1 0.00	463
CU	16 0.11	51 0.36	19 0.13	5 0.04	2 0.01	1 0.01	16 0.11	20 0.14	11 0.08	0 0.0	141
SC	20 0.17	20 0.17	16 0.14	7 0.06	1 0.01	1 0.01	21 0.18	13 0.11	16 0.14	1 0.01	116
ST	4 0.18	0 0.0	5 0.23	4 0.18	0 0.0	0 0.0	7 0.32	0 0.0	2 0.09	0 0.0	22
CS	10 0.21	6 0.13	7 0.15	3 0.06	1 0.02	0 0.0	10 0.21	7 0.15	4 0.08	0 0.0	48
AS	9 0.26	5 0.15	6 0.18	0 0.0	0 0.0	0 0.0	9 0.26	3 0.09	2 0.06	0 0.0	34
AC	41 0.16	24 0.09	31 0.12	16 0.06	4 0.02	4 0.02	66 0.26	44 0.17	27 0.11	0 0.0	257
CI	37 0.24	22 0.14	17 0.11	5 0.03	3 0.02	0 0.0	21 0.13	39 0.25	12 0.08	0 0.0	156
CS	101 0.24	51 0.12	43 0.10	15 0.04	9 0.02	5 0.01	91 0.22	63 0.15	38 0.09	1 0.00	417
NS	1 0.33	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1 0.33	1 0.33	0 0.0	3

TABLE B-5A

SPATIAL CONDITIONALS: CHINA LAKE, CALIFORNIA - LAS VEGAS, NEVADA

SPATIAL CONDITIONALS

ANCHOR STATION CHINA LAKE CALIF TO LAS VEGAS NEVADA

MONTH 1 YEAR 58 THRU 67

DIST (NM) = 120.06

CT	CLR	CU	SC	ST	CB	AS	AC	CI	CS	NS	TOTAL
CL	674	10	20	0	2	3	27	111	27	0	874
	0.77	0.01	0.02	0.0	0.00	0.00	0.03	0.13	0.03	0.0	
CU	0	7	4	2	0	0	1	0	6	0	20
	0.0	0.35	0.20	0.10	0.0	0.0	0.05	0.0	0.30	0.0	
SC	22	8	35	7	0	5	19	8	11	2	117
	0.19	0.07	0.30	0.06	0.0	0.04	0.16	0.07	0.09	0.02	
ST	0	0	3	1	0	0	2	0	2	0	8
	0.0	0.0	0.38	0.13	0.0	0.0	0.25	0.0	0.25	0.0	
CB	1	0	0	0	0	0	0	0	0	0	1
	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
AS	4	1	6	0	0	5	10	12	12	1	51
	0.08	0.02	0.12	0.0	0.0	0.10	0.20	0.24	0.24	0.02	
AC	25	3	58	3	0	5	36	50	62	1	243
	0.10	0.01	0.24	0.01	0.0	0.02	0.15	0.21	0.26	0.00	
CI	154	6	7	0	0	2	17	174	131	0	491
	0.31	0.01	0.01	0.0	0.0	0.00	0.03	0.35	0.27	0.0	
CS	66	2	12	0	0	1	14	131	125	0	351
	0.19	0.01	0.03	0.0	0.0	0.00	0.04	0.37	0.36	0.0	
NS	1	1	2	1	0	0	1	0	1	0	7
	0.14	0.14	0.29	0.14	0.0	0.0	0.14	0.0	0.14	0.0	

TABLE B-5B

SPATIAL CONDITIONALS: CHINA LAKE, CALIFORNIA - LAS VEGAS, NEVADA

SPATIAL CONDITIONALS

ANCHOR STATION CHINA LAKE CALIF TO LAS VEGAS NEVADA

MONTH 7 YEAR 58 THRU 67

DIST (NM) = 120.06

CT	CLR	CU	SC	ST	CB	AS	AC	CI	CS	NS	TOTAL
CL	950	39	38	0	20	1	88	112	20	0	1268
	0.75	0.03	0.03	0.0	0.02	0.00	0.07	0.09	0.02	0.0	
CU	46	35	8	0	33	0	18	22	4	0	166
	0.28	0.21	0.05	0.0	0.20	0.0	0.11	0.13	0.02	0.0	
SC	0	0	2	0	1	0	0	0	0	0	3
	0.0	0.0	0.67	0.0	0.33	0.0	0.0	0.0	0.0	0.0	
ST	0	0	0	0	0	0	0	0	0	0	0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CB	4	9	0	0	17	0	6	10	2	0	48
	0.08	0.19	0.0	0.0	0.35	0.0	0.13	0.21	0.04	0.0	
AS	1	1	0	0	2	0	2	0	0	0	6
	0.17	0.17	0.0	0.0	0.33	0.0	0.33	0.0	0.0	0.0	
AC	32	22	15	0	29	1	66	64	15	0	244
	0.13	0.09	0.06	0.0	0.12	0.00	0.27	0.26	0.06	0.0	
CI	38	16	9	0	15	0	27	106	38	0	249
	0.15	0.06	0.04	0.0	0.06	0.0	0.11	0.43	0.15	0.0	
CS	21	8	6	0	6	0	5	38	14	0	98
	0.21	0.08	0.06	0.0	0.06	0.0	0.05	0.39	0.14	0.0	
NS	0	0	0	0	0	0	0	0	0	0	0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

APPENDIX C

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LEVEL 21.6 ( MAY 72 )

          COMPILER OPTIONS = NAME=  MAIN,OPT=00,LINECNT=50,SIZE=0000K,        OS/360  FORTRAN H
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
 ISN 0002              SUBROUTINE CTENTH(N,IR,NC)
                 C     ***********************************************************************
                 C      VERSION 1.0     LEVEL 731205
                 C     GIVEN A CLOUD COVER CATEGORY , THIS ROUTINE WILL
                 C     RETURN WITH NC EQUAL TO THE CLOUD COVER IN TENTHS.
                 C     N=CLOUD COVER CATEGORY.
                 C     IR=NUMBER FOR RANDM SUBROUTINE
                 C     ***********************************************************************
 ISN 0003              DIMENSION C2(3),C3(4)
 ISN 0004              DATA C2/.33,.66,1.00/,  C3/.25,.50,.75,1.00/
 ISN 0005              IF(N.GT.1)GO TO 2
 ISN 0007              NC=0
 ISN 0008              RETURN
 ISN 0009            2 IF(N.LT.5)GO TO 3
 ISN 0011              NC=10
 ISN 0012              RETURN
 ISN 0013            3 CALL RANDM(IR,RAN)
 ISN 0014              IF(N.EQ.2)GO TO 23
 ISN 0016              IF(N.EQ.3)GO TO 20
 ISN 0018              DO 18 J=1,4
 ISN 0019              IF(RAN.LE.C3(J))GO TO 19
 ISN 0021           18 CONTINUE
 ISN 0022           19 NC=J+5
 ISN 0023              RETURN
 ISN 0024           20 DO 21 J=1,3
 ISN 0025              IF(RAN.LE.C2(J))GO TO 22
 ISN 0027           21 CONTINUE
 ISN 0028           22 NC=J
 ISN 0029              RETURN
 ISN 0030           23 NC=2
 ISN 0031              IF(RAN.LE.0.5)NC=1
 ISN 0033              RETURN
 ISN 0034              END
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REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR.

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