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THUNDERSTORM PERSISTENCE AT CAPE KENNEDY, FLORIDA

Prepared under Government Order No. H-76789 by
Russell F. Lee, James W. Ownbey, and Frank T. Quinlan

NATIONAL WEATHER RECORDS CENTER

For

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER
Marshall Space Flight Center, Alabama

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NATIONAL WEATHER RECORDS CENTER
Asheville, North Carolina

Contract Monitors: Orvel E. Smith and S. C. Brown
Aerospace Environment Division
Aero-Astrodynamics Laboratory

NASA - GEORGE C. MARSHALL SPACE FLIGHT CENTER

TABLE OF CONTENTS

THUNDERSTORM PERSISTENCE AT CAPE KENNEDY, FLORIDA

SUMMARY

The probabilities and conditional probabilities of sequences of days with and without thunderstorms at Cape Kennedy, Florida, are determined for given months and seasons, and for specified periods of the day. These periods are as follows:

(1) Each hour of the day beginning with 0000-0059 EST (for thunderstorm probabilities only);

(2) The 4-hour periods 0000-0359, 0400-0759, 0800-1159, 1200-1559, 1600-1959 and 2000-2359 EST;

(3) The 8-hour periods 0000-0759, 0400-1159, 0800-1559, 1200-1959 and 1600-2359 EST; and

(4) The 24-hour period 0000-2359 EST.

Data used in this study are for the period January 1957 through December 1962.

Conditional probabilities of sequences of thunderstorms are computed for all times except the one-hour periods. The highest wind speeds associated with thunderstorms are examined for the 24-hour period for each month and season of the year and for the period 1200 through 1959 EST for June, July, and August and for the summer season only (June, July, and August combined).

The distributions of sequences of days with and without thunderstorms during the hours 1200 through 1959 EST for June, July, August and the summer season are compared with the persistence series suggested by Eggenberger and Polya, and the Markov chain model of the zero, first and second orders. The comparisons are tested by using the Chi-square and the Kolmogorov-Smirnov statistical tests.

I. INTRODUCTION

This report represents part of a continuing evaluation of meteorological data affecting aerospace operations at Cape Kennedy, Florida. Relative frequencies of thunderstorm occurrences at Cape Kennedy are available in the Summary of Monthly Aerological Records (SMAR) format for each month, which was prepared for the National Aeronautics and Space Administration by the National Weather Records Center in Asheville, North Carolina.

Because the lightning and high surface winds associated with thunderstorms hinder the launch operations at Cape Kennedy, information is presented on probabilities and conditional probabilities of thunderstorms and on the distribution of the highest wind speeds during thunderstorms.

Dr. Harold L. Crutcher's consultation and guidance in the preparation of this report are gratefully appreciated.

II. STATEMENT OF THE PROBLEM

The probabilities and conditional probabilities of sequences of thunderstorms at Cape Kennedy, Florida, are needed for given months and seasons, and for specified periods of the day. These periods are as follows:

(a) Each hour of the day beginning with 0000-0059 EST (for thunderstorm probabilities only);

(b) The 4-hour periods 0000-0359, 0400-0759, 0800-1159, 1200-1559, 1600-1959 and 2000-2359 EST;

(c) The 8-hour periods 0000-0759, 0400-1159, 0800-1559, 1200-1959 and 1600-2359 EST; and

(d) The 24-hour period 0000-2359 EST.

Conditional probabilities of sequences of thunderstorms are to be computed for all times except the one-hour periods. The highest wind speeds associated with thunderstorms are to be examined for the 24-hour period and for the period 1200 through 1959 EST for the summer season only. To answer specific questions concerning sequences of thunderstorm occurrences, the distribution of sequences of days without thunderstorms also must be determined. The conditional probabilities for sequences of days with and without thunderstorms for only the summer season will be examined because most of the thunderstorms at Cape Kennedy occur during the summer months.

III. SOURCE OF DATA

All of the data for this study are from the Surface Weather Observation Record (Forms WBAN 10-A and B) for Cape Kennedy, Florida, for the period January 1957 through December 1962. A thunderstorm is reported on Form WBAN 10 whenever thunder is heard at the station within the 15 minutes before the observation [1].

IV. PROCEDURES

A. Data Organization

The occurrences of thunderstorms are first listed by year, month, day and hour. The frequencies of days with thunderstorms during each hour are tallied by month and by season. Relative frequencies, computed by dividing these counts by the total number of days, are shown in tables A1.1 and A1.2 in Appendix A.

The frequency of days with thunderstorms during the specified 4-, 8-, and 24-hour periods also are tallied by month for June, July and August, and for the summer season (June through August combined). In addition, sequences of 2, 3, ..., 12 days are tallied with thunderstorms and without thunderstorms during the specified time periods. Each sequence is tallied in the month in which the first day of that sequence fell. For example, if thunderstorms were observed on July 30 and 31, and August 1 and 2, two sequences of two (30-31 and 31-1) would be tallied for July and one for August (August 1 and 2).

To further illustrate how the thunderstorm sequences are tallied, consider the following sequences of days with thunderstorms (indicated by T) and with no thunderstorms (indicated by N) from Cape Kennedy, Florida, WBAN 10 records for the hours 1200-1559 EST during July 1957.

July 1957	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Thunderstorm	N	T	T	T	N	N	N	N	N	T	T	T	T	N	T

July 1957	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Thunderstorm Occurrence	N	T	N	T	N	N	N	N	T	T	N	N	T	T	T	T

August 1957	1	2	3	4	5
Thunderstorm Occurrence	T	T	T	T	N

The frequencies of sequences of various lengths are tallied as follows:

Length of Sequence of Thunderstorm Days	No. of Sequences Tallied for July 1957	
1	16	(2,3,4,10,11,12,13,15,17,19,24,25,28,29 30,31)
2	10	(2-3,3-4,10-11,11-12,12-13,24-25,28-29, 29-30,30-31,31-1)
3	7	(2-4,10-12,11-13,28-30,29-31,30-1,31-2)
4	5	(10-13,28-31,29-1,30-2,31-3)
5	4	(28-1,29-2,30-3,31-4)
6	3	(28-2,29-3,30-4)
7	2	(28-3,29-4)
8	1	(28-4).

Notice that, while the initial day of each sequence must be in the month being tallied, successive days within that sequence need not be. The 2-day sequence of July 31 through August 1 is tallied in July, but the sequence August 1 through 2 is counted in August. From July 28 to August 4 an 8-day sequence is tallied in July.

Notice, also, that one run may contain a large number of sequences. A run of 4 days for example, contains one sequence of four, 2 sequences of three, 3 sequences of two, and 4 sequences of one.

The conditional probabilities are computed from the frequencies of sequences by the equation $p(k|i) = F(k+i)/F(i)$, where $p(k|i)$ is the conditional probability of having k additional consecutive days of an occurrence of an event (either a thunderstorm or lack of a thunderstorm), given that i consecutive days of this event have just occurred with no information about events prior to this; $F(i)$ is the frequency of occurrence of a sequence of length i; and $F(k+i)$ is the frequency of occurrence of a sequence of length k+i.

When i = 0, then $F(0)$ is the frequency of days for which the presence or absence of the event is not specified, hence $F(0) = N$, which is the total number of days in the sample. The probability of k, given no previous information, is given by $p(k|0)$. Thus, $p(k|0)$ may be read as, simply, $p(k)$.

The conditional probabilities of sequences of thunderstorms occurring within the specified 4-hour periods are shown in tables A2.1 through A2.5 in Appendix A by month and season, and within the 8-hour and 24-hour periods in tables A3.1 through A3.5 by month and season.

The conditional probabilities of thunderstorms not occurring within the specified 4-hour periods are shown in tables A4.1 through A4.12 in Appendix A by month and season, and not occurring within the 8-hour and 24-hour periods in tables A5.1 through A5.12 by month and season.

The use of these tables is described by two examples. Suppose the probability is required of the occurrence of two consecutive August days with thunderstorms between 1200 and 1559 EST at Cape Kennedy, Florida, given that thunderstorms have occurred during these hours on each of the previous three consecutive days. The answer is in table A2.3 in Appendix A, which is the table corresponding to the hours 1200 through 1559 EST. The intersection of the row i = 3 (three consecutive days of thunderstorms have already occurred) with column k = 2 (to find the probability of two additional days of thunderstorms) in the tabulation for August yields the probability of .400.

If the probability is required of three consecutive days during the summer with no thunderstorms between 1200 and 1959 EST, locate the table for these hours, which is table A5.8 on page 32 of Appendix A.

As there is no information on the occurrence or non-occurrence of thunderstorms prior to the time in question, the desired probability is found at the intersection of row i = 0 and column k = 3 in the tabulation for the summer season. The probability of three consecutive summer days with no thunderstorms is found to be .317.

The frequency distribution of maximum wind speeds associated with thunderstorms is presented in tables A6.1 and A6.2 in Appendix A. This distribution is determined by examining the Forms WBAN 10-A and B for each day during which a thunderstorm occurred. The peak thunderstorm gust recorded for the day is used. If this figure is not available, the highest reported wind during and within 30 minutes either side of the thunderstorms of the day is substituted.

B. Development of Theoretical Models

The distribution of sequences of days with and without thunderstorms between the hours 1200 and 1959 EST during the months of June, July, and August and the summer season (June through August combined) is compared with the persistence series and the Markov chain model of the zero, first and second orders. This season and time of day are selected because most of the thunderstorms at Cape Kennedy occur between these afternoon hours and during the summer months. Other time periods have insufficient numbers of thunderstorms to provide good comparisons with the theoretical models.

The observed frequencies of sequences of thunderstorm and of non-thunderstorm occurrences are compared with the theoretical distributions predicted by the Markov chain model and by the persistence series of Eggenberger and Polya [3]. According to Brooks and Carruthers [2], following Eggenberger and Polya [3], the persistence series is defined as:

$$\frac{1}{(1 + d')^{m/d'}}, \quad \frac{m}{1!\ (1 + d')^{m/d'+1}}, \quad \frac{m(m + d')}{2!\ (1 + d')^{m/d'+2}}, \quad \ldots,$$

$$\frac{m(m + d')(m + 2d') \ldots (m + [i - 1]\ d')}{i!\ (i + d')^{m/d'+i}}$$

where m is the mean of the observed series and d' = ([illegible] - 1. The variance is σ^2 and i = [illegible] 1, where p is the length of the longest sequence to be determined.

The zero order Markov model [5] is constructed by assuming that the probability of an event occurring on a given day is independent of any previous occurrences. If the probability of a thunderstorm occurring on a certain day is .400, then the theoretical probability of thunderstorms occurring on two successive days is .400 x .400 = .160. Likewise, the probability of a three-day sequence of thunderstorms is $(.400)^3 = .064$. Thus, assuming a zero order Markov model, the probability of a sequence of n days of events (E) counting from any given day is $P_n = [p(E)]^n$. For the purposes of this paper, an event will be either the occurrence or the non-occurrence of a thunderstorm.

The assumption of a first order Markov process is the assumption that the probability of an event occurring depends upon the occurrence or non-occurrence of the event on the previous day, but is independent of any other prior occurrences. Then the probability of an event occurring two days in succession is $p_2 = p(E) \times p(E|E)$ where $p(E|E)$ is the probability of the event E, given that such an event has occurred on the previous day. Thus, the probability of sequence of n events is

$$p_n = p(E) \times [p(E|E)]^{n-1}.$$

In a similar manner, the second order Markov [illegible] assumes that the probability of an event is dependent only upon its occurrence or non-occurrence during the previous two days. The equation for the second order Markov series is a logical extension of the first order:

$$p_n = p(E) \times p(E|E) \times [p(E|EE)]^{n-2} \quad \text{for } n \geq 2,$$

where $p(E|EE)$ is the probability of an event occurring, given that it has already occurred on each of the two preceding days.

If a specific distribution of sequences of thunderstorm and non-thunderstorm afternoons is assumed to be Markovian, then the order of the Markov series best representing the data can be determined by use of the asymptotic Chi-square statistic, which is described in Appendix B [5]. This test was applied to the sequences of the occurrences and non-occurrences of thunderstorms during the summer within the period 1200 through 1959 EST. The resulting X^2 values are shown in table 1.1.

The Markov processes, zero through second order, and the persistence series are compared with the observed relative frequency distributions of the occurrences of thunderstorms within the same time periods used above.

The Kolmogorov-Smirnov test [4] is used to test the goodness of fit. This test uses the maximum difference between the observed and theoretical cumulative distributions of days with or without thunderstorms as the argument with which to determine whether the distributions are significantly different. As the longer sequences include the shorter sequences within them, frequencies of sequences of days with and without thunderstorms shown in tables 2.1 and 2.2 are already in the form of cumulative distributions beginning with the longer sequences. It is only necessary to divide each frequency by the frequency of the shortest sequence, namely, the frequency of the sequences of one day with or without thunderstorms. Then take the maximum difference between the observed and theoretical distributions and compare it with the value for $\alpha = .20$. If the argument is greater than the limiting argument for α = .20, then the null hypothesis is not accepted that the distribution of sequences of thunderstorms is the same as the theoretical distribution.

V. RESULTS

As shown in table A1.2, 46.6 percent of the summer days contain thunderstorms, while less than 20 percent of the days in any of the other seasons contain thunderstorms. The probability of a thunderstorm occurring is greatest during the period 1200 through 1959 EST, that probability being .420 for the summer season. The probability of a thunderstorm occurring during an adjacent period, 0400 through 1159 EST, is only .109. A comparison of tables A3.3 and A3.5 reveals that the distributions of sequences of thunderstorms are essentially the same for the period 1200 through 1959 EST as for the entire day (0000 through 2359 EST). In fact, during the summer season, more than 90 percent of the days during which thunderstorms are reported contain thunderstorms during the period 1200 through 1959 EST.

If the observed distribution of sequences of days with and without thunderstorms is Markovian, then the order of the Markov distribution which fits the observed distribution is determined by using the Chi-square test. The results of such a test are shown in table 1.1. The zero order Markov model is not accepted at the α = .01 level for any of the summer months nor for the summer season. The first and second order Markov models fit the distributions of sequences of days with and sequences of days without thunderstorms. Since the second order Markov model requires more input data, the first order model is considered adequate.

The results of the Kolmogorov-Smirnov test comparing the distribution of the sequences of thunderstorms with the distribution predicted by the persistence series of Eggenberger and Polya and the zero, first, and second order Markov chain models (table 3.1) indicate that all the distributions except the zero order Markov are acceptable approximations to the observed distribution. The persistence series, while roughly equivalent to the first order Markov in accuracy, is much more difficult to compute. It is for this reason that the persistence series is omitted from the study of sequences of days without thunderstorms. The actual distributions and the first order Markov expected distributions of the sequences of days with thunderstorms during the hours 1200 through 1959 EST in June, July, and August and the summer season are shown graphically in figures 1 through 4.

Table 3.2 shows the results of the Kolmogorov-Smirnov test applied to the zero, first, and second order estimates of the distribution of sequences of days without thunderstorms between 1200 and 1959 EST. In this case, the first order Markov model is not accepted at the α = .20 level for June and the summer season, but is accepted for July and August.

The first order Markov model is found to fit the distributions of sequences of days without afternoon thunderstorms during July and August; however, the second order Markov model is required to fit the distributions of sequences during June and the summer season.

Tables A6.1 and A6.2 in Appendix A show the distribution of thunderstorm winds. Notice that the median wind speeds for the summer season and for the year as a whole are between 15 and 19 knots. No comparison between the thunderstorm wind distribution for days with thunderstorms and the distributions for days without thunderstorms is made.

Partial results of this study were presented [6] at the symposium held at the Marshall Space Flight Center in December 1966.

VI. CONCLUSIONS

The first order Markov model may be used to approximate the distribution of sequences of summer afternoons with thunderstorms. The second order Markov model may be used to approximate the distribution of sequences of summer afternoons without thunderstorms.

Table 1.1

Results of the Chi-square test to determine which order of the Markov model applies assuming the distribution is Markovian. The data being tested are the distributions of sequences of days with and without thunderstorms occurring at Cape Kennedy, Florida, between 1200 and 1959 EST during June, July, August and the summer season, for the years 1957 through 1962.

	Zero Order	First Order	Second Order
June	23.68453**	8.36120	3.11543
July	39.56622**	5.41721	4.57970
August	21.21101**	4.59896	4.30371
Summer	76.39713**	9.82338	6.18184
df	7	6	4

**Indicates theoretical and observed distributions are significantly different at the 0.01 probability level.

Table 2.1

The observed and theoretical relative frequencies of sequences of days with thunderstorms between 1200 and 1959 EST at Cape Kennedy, Florida, for the years 1957 through 1962.

	Length of Sequences in Days											
	1	2	3	4	5	6	7	8	9	10	11	12
1200-1959 EST	June											
Observed	.406	.228	.133	.073	.033	.017	.006					
Persistence Series	.407	.229	.125	.067	.035	.018	.010					
Zero Order Markov	.406	.164	.067	.027	.011	.004	.002					
First Order Markov	.406	.228	.128	.072	.040	.023	.013					
Second Order Markov	.406	.228	.133	.078	.046	.027	.016					
1200-1959 EST	July											
Observed	.441	.312	.226	.161	.113	.081	.054	.038	.022	.016	.011	.005
Persistence Series	.431	.303	.210	.145	.100	.068	.046	.030	.020	.013	.008	.004
Zero Order Markov	.441	.194	.086	.038	.017	.007	.003	.001	.001	.000	.000	.000
First Order Markov	.441	.312	.221	.156	.110	.078	.055	.039	.028	.020	.014	.011
Second Order Markov	.441	.312	.226	.164	.118	.086	.062	.045	.033	.024	.017	.012
1200-1959 EST	August											
Observed	.414	.237	.140	.091	.059	.038	.022	.016	.011	.005		
Persistence Series	.371	.214	.105	.043	.008	.003						
Zero Order Markov	.414	.171	.021	.029	.012	.005	.002	.001	.000	.000		
First Order Markov	.414	.237	.135	.077	.044	.025	.014	.008	.005	.003		
Second Order Markov	.414	.237	.140	.083	.049	.029	.017	.010	.006	.004		
1200-1959 EST	Summer											
Observed	.420	.259	.167	.109	.069	.045	.027	.018	.011	.007	.004	.002
Persistence Series	.416	.255	.161	.102	.065	.041	.037	.017	.011	.007	.004	.003
Zero Order Markov	.420	.177	.074	.031	.013	.006	.002	.001	.000	.000	.000	.000
First Order Markov	.420	.259	.160	.098	.061	.037	.023	.014	.009	.005	.003	.002
Second Order Markov	.420	.259	.167	.107	.069	.044	.029	.018	.012	.008	.005	.003

Table 2.2

The observed and theoretical relative frequencies of sequences of days without thunderstorms between 1200 and 1959 EST at Cape Kennedy, Florida, for the years 1957 through 1962.

	Length of Sequences in Days											
	1	2	3	4	5	6	7	8	9	10	11	12
1200-1959 EST	June											
Observed	.594	.417	.322	.261	.211	.161	.133	.106	.083	.067	.050	.044
Zero Order Markov	.594	.353	.210	.125	.074	.044	.026	.016	.009	.006	.003	.002
First Order Markov	.594	.417	.292	.205	.143	.101	.070	.049	.035	.024	.017	.012
Second Order Markov	.594	.417	.322	.249	.193	.149	.115	.089	.069	.053	.041	.032
1200-1959 EST	July											
Observed	.559	.419	.312	.237	.183	.151	.129	.108	.097	.086	.075	.065
Zero Order Markov	.559	.313	.175	.098	.055	.031	.017	.010	.005	.003	.002	.001
First Order Markov	.559	.419	.315	.236	.177	.133	.100	.075	.056	.042	.031	.024
Second Order Markov	.559	.419	.312	.232	.172	.128	.095	.071	.053	.039	.029	.022
1200-1959 EST	August											
Observed	.586	.419	.317	.253	.188	.134	.097	.065	.043	.032	.022	.011
Zero Order Markov	.586	.343	.201	.118	.069	.041	.024	.014	.008	.005	.003	.002
First Order Markov	.586	.419	.300	.215	.154	.110	.079	.056	.040	.029	.021	.015
Second Order Markov	.586	.419	.317	.240	.181	.137	.104	.079	.059	.045	.034	.026
1200-1959 EST	Summer											
Observed	.580	.418	.317	.250	.194	.149	.120	.092	.074	.062	.049	.040
Zero Order Markov	.580	.336	.195	.113	.065	.038	.022	.013	.007	.004	.002	.001
First Order Markov	.580	.418	.302	.218	.157	.114	.082	.059	.043	.031	.022	.016
Second Order Markov	.580	.418	.317	.240	.182	.138	.104	.079	.060	.045	.034	.026

Table 3.1

The application of the "Kolmogorov-Smirnov" test to the maximum differences between the observed and theoretical cumulative distributions of sequences of days with thunderstorms occurring at Cape Kennedy, Florida, between 1200 and 1959 EST for June, July, August and the summer season (1957-1962).

	June	July	August	Summer
Persistence Series	.022	.036	.016	.016
Zero Order Markov	.164*	.318*	.166*	.225*
First Order Markov	.018	.014	.036	.030
Second Order Markov	.030	.025	.025	.007
N-Count	73	82	77	232
$\alpha = 0.20$	.125	.118	.122	.070

*Indicates the null hypothesis is not accepted.

Null hypothesis: The distribution of sequences of days with thunderstorms between 1200 and 1959 EST at Cape Kennedy, Florida, occurs according to the indicated theoretical distributions.

Results: For all periods considered, the zero order Markov model is not accepted. The first and second order Markov models and the persistence series are accepted.

Table 3.2

The application of the "Kolmogorov-Smirnov" test to the maximum differences between the observed and theoretical cumulative distributions of sequences of days without thunderstorms occurring at Cape Kennedy, Florida, between 1200 and 1959 EST for June, July, August and the summer season (1957-1962).

	June	July	August	Summer
Zero Order Markov	.230*	.248*	.230*	.237*
First Order Markov	.114*	.079	.065	.065*
Second Order Markov	.031	.084	.028	.028
N-Count	107	104	109	320
α = .20	.103	.105	.102	.060

*Indicates the null hypothesis is not accepted.

Null hypothesis: The distribution of sequences of days without thunderstorms between 1200 and 1959 EST at Cape Kennedy, Florida, occurs according to the indicated theoretical distributions.

Results: For June and the summer season, the zero and first order Markov models are not accepted; the second order Markov model is accepted. For July and August, the zero order Markov model is not accepted; the first and second order Markov models are accepted.

Figure 1

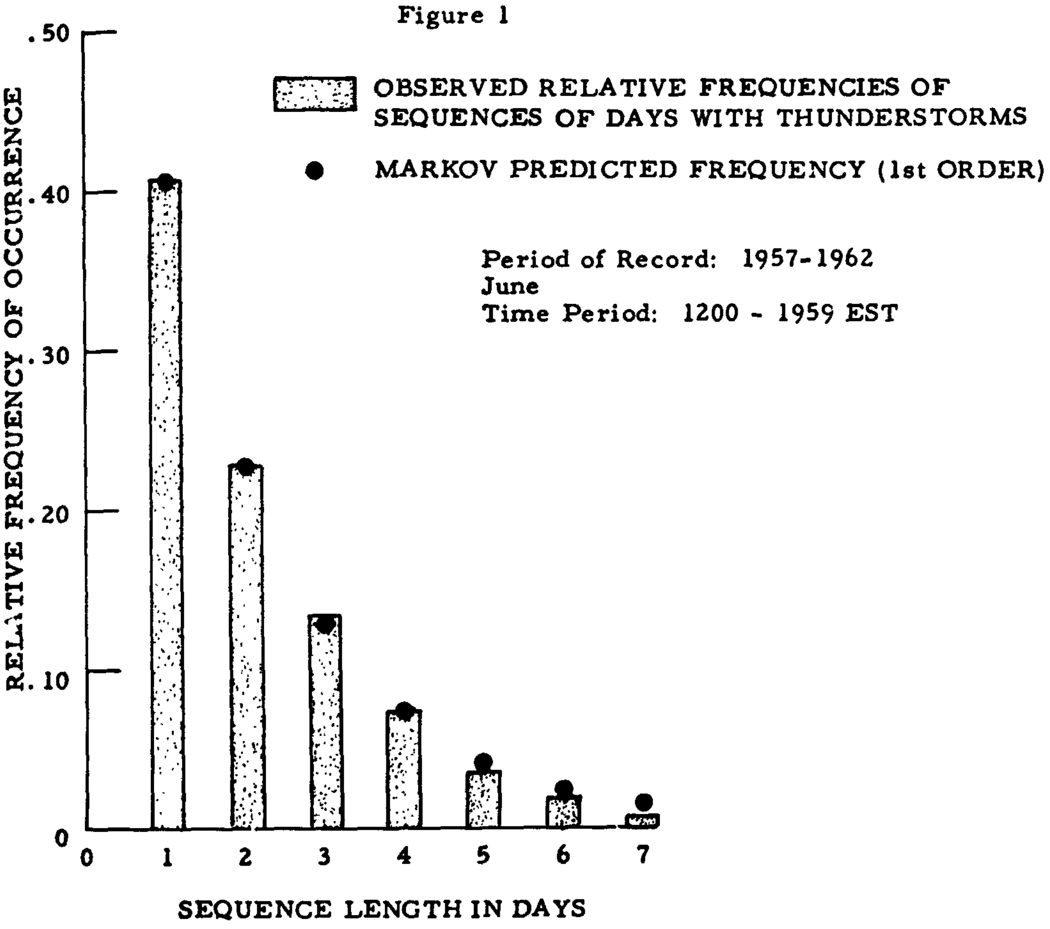

Figure 1. Comparison of the observed and the first order Markov predicted relative frequencies of sequences of days in June with thunderstorms occurring between 1200 and 1959 EST.

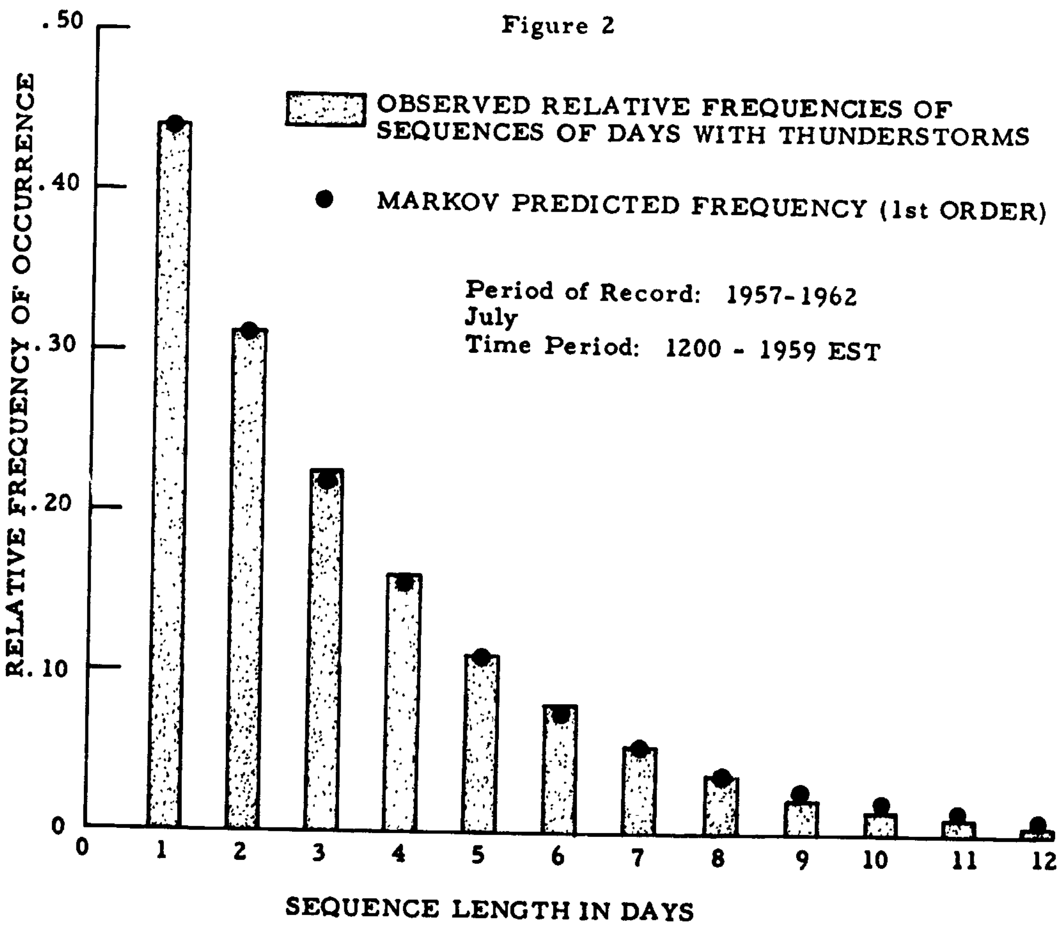

Figure 2. Comparison of the observed and the first order Markov predicted relative frequencies of sequences of days in July with thunderstorms occurring between 1200 and 1959 EST.

Figure 3

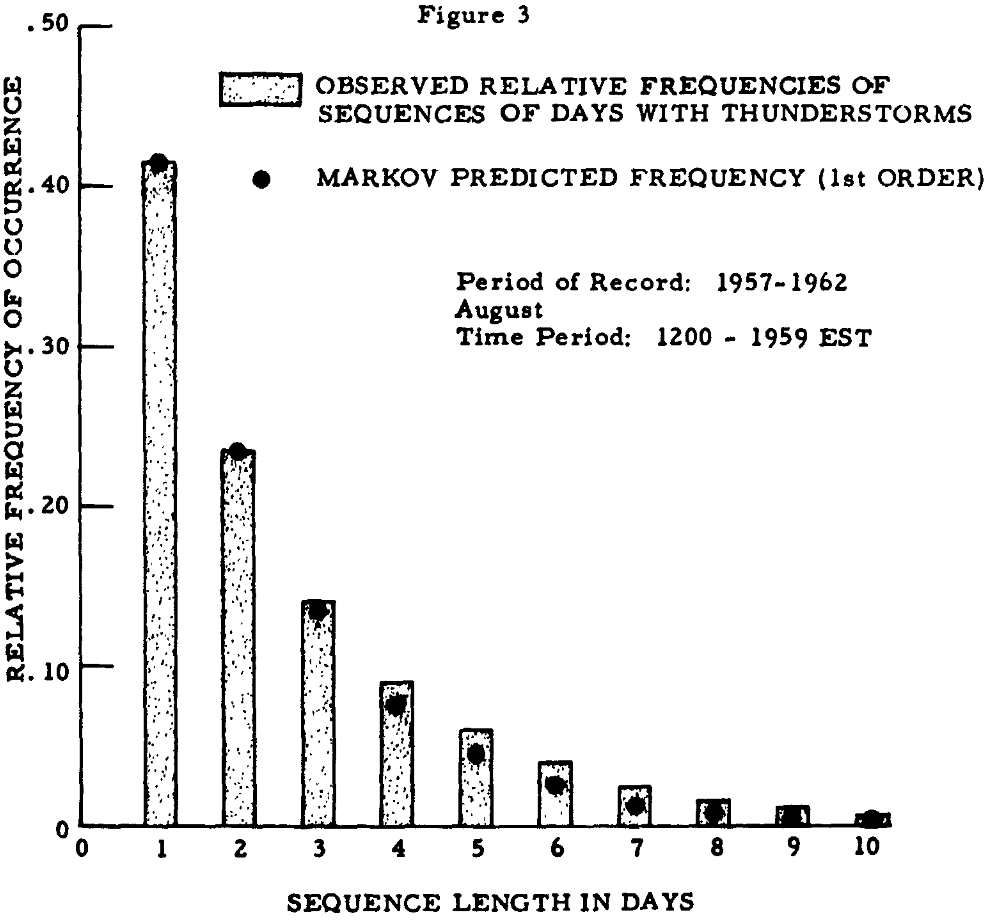

Figure 3. Comparison of the observed and the first order Markov predicted relative frequencies of sequences of days in August with thunderstorms occurring between 1200 and 1959 EST.

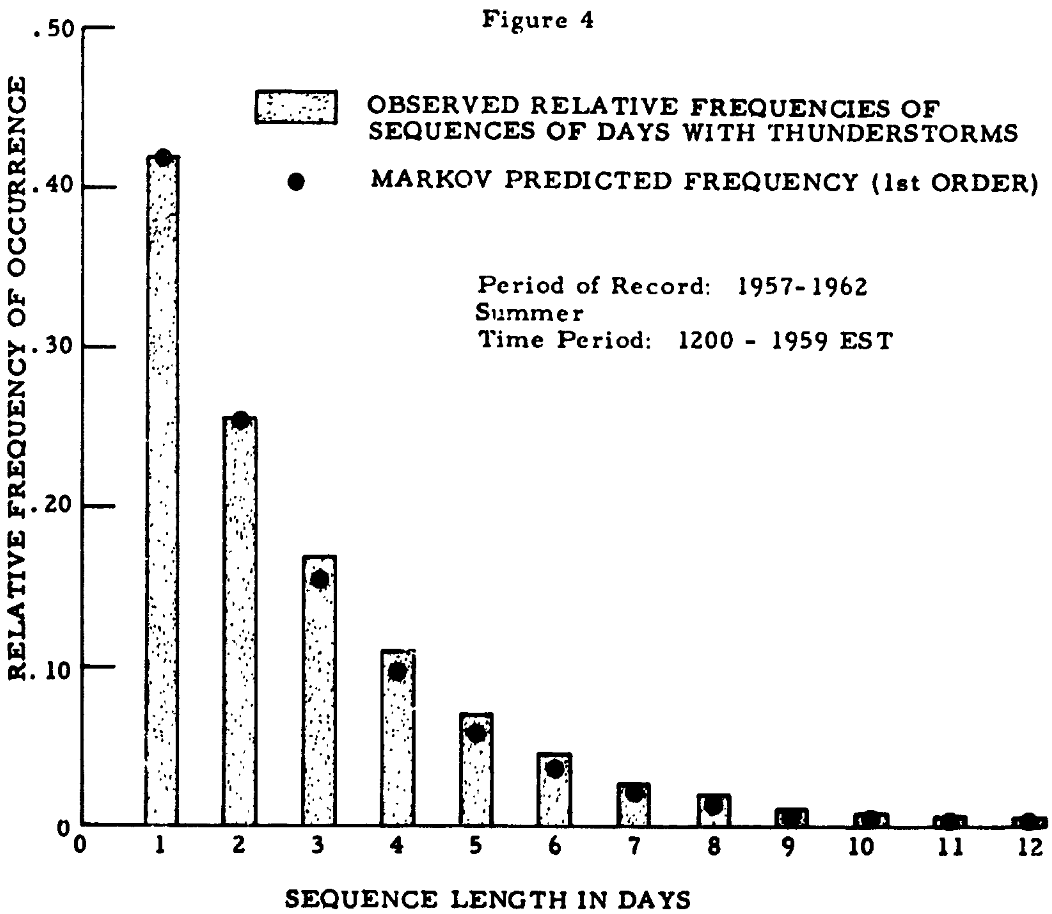

Figure 4. Comparison of the observed and the first order Markov predicted relative frequencies of sequences of days during the summer season with thunderstorms occurring between 1200 and 1959 EST.

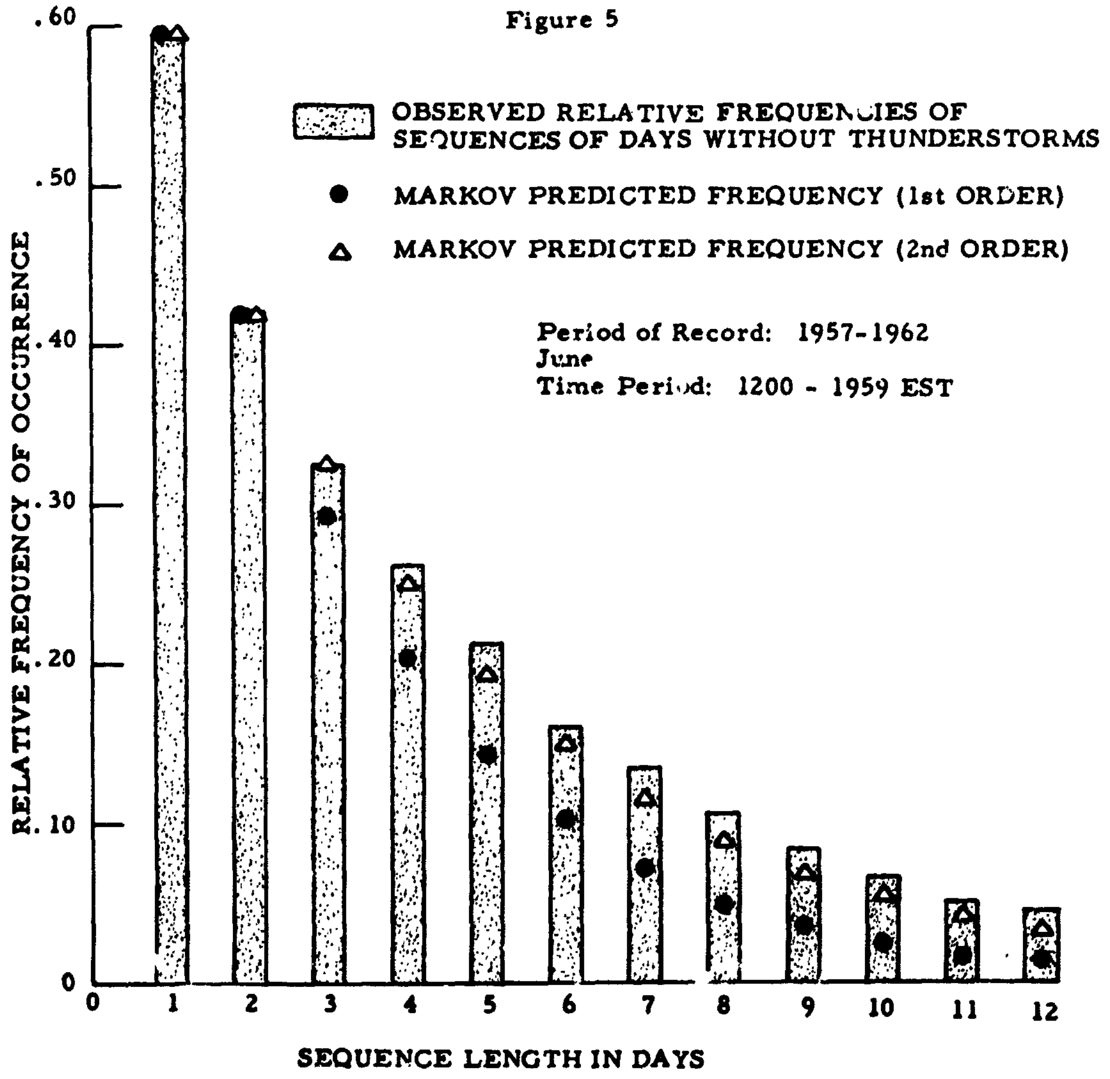

Figure 5. Comparison of the observed and the first and second order Markov predicted relative frequencies of sequences of days in June without thunderstorms occurring between 1200 and 1959 EST.

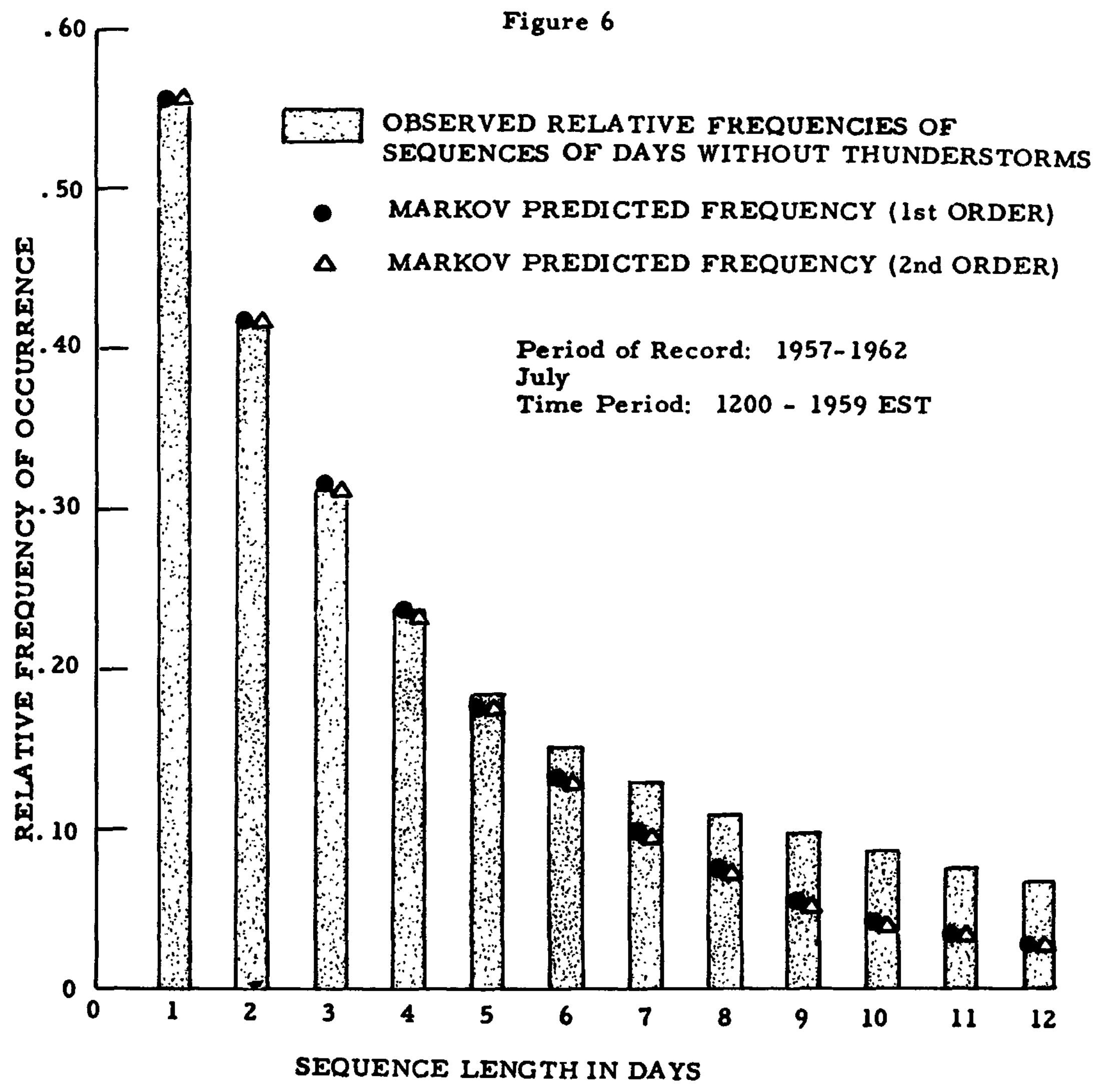

Figure 6. Comparison of the observed and the first and second order Markov predicted relative frequencies of sequences of days in July without thunderstorms occurring between 1200 and 1959 EST.

Figure 7

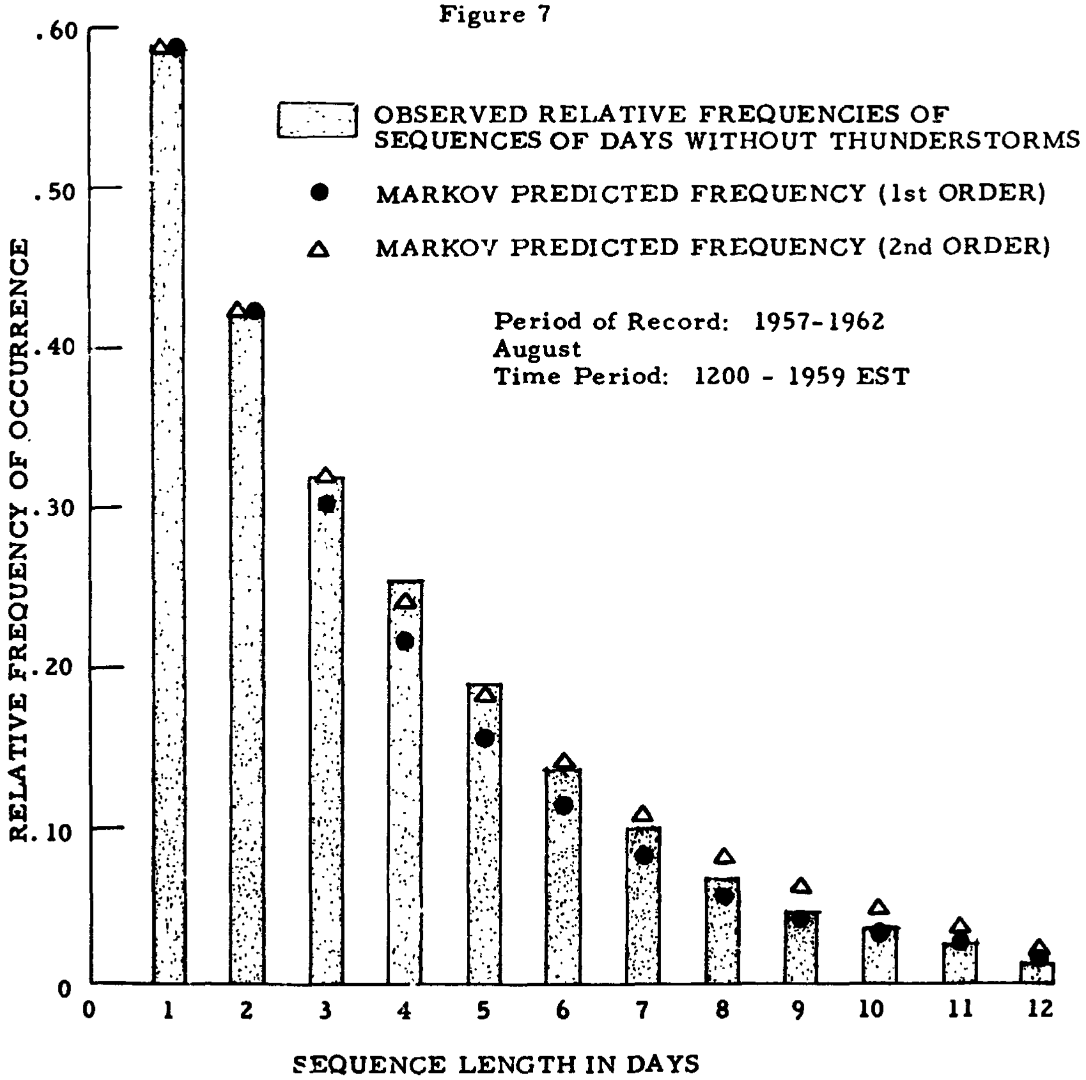

Figure 7. Comparison of the observed and the first and second order Markov predicted relative frequencies of sequences of days in August without thunderstorms occurring between 1200 and 1959 EST.

Figure 8

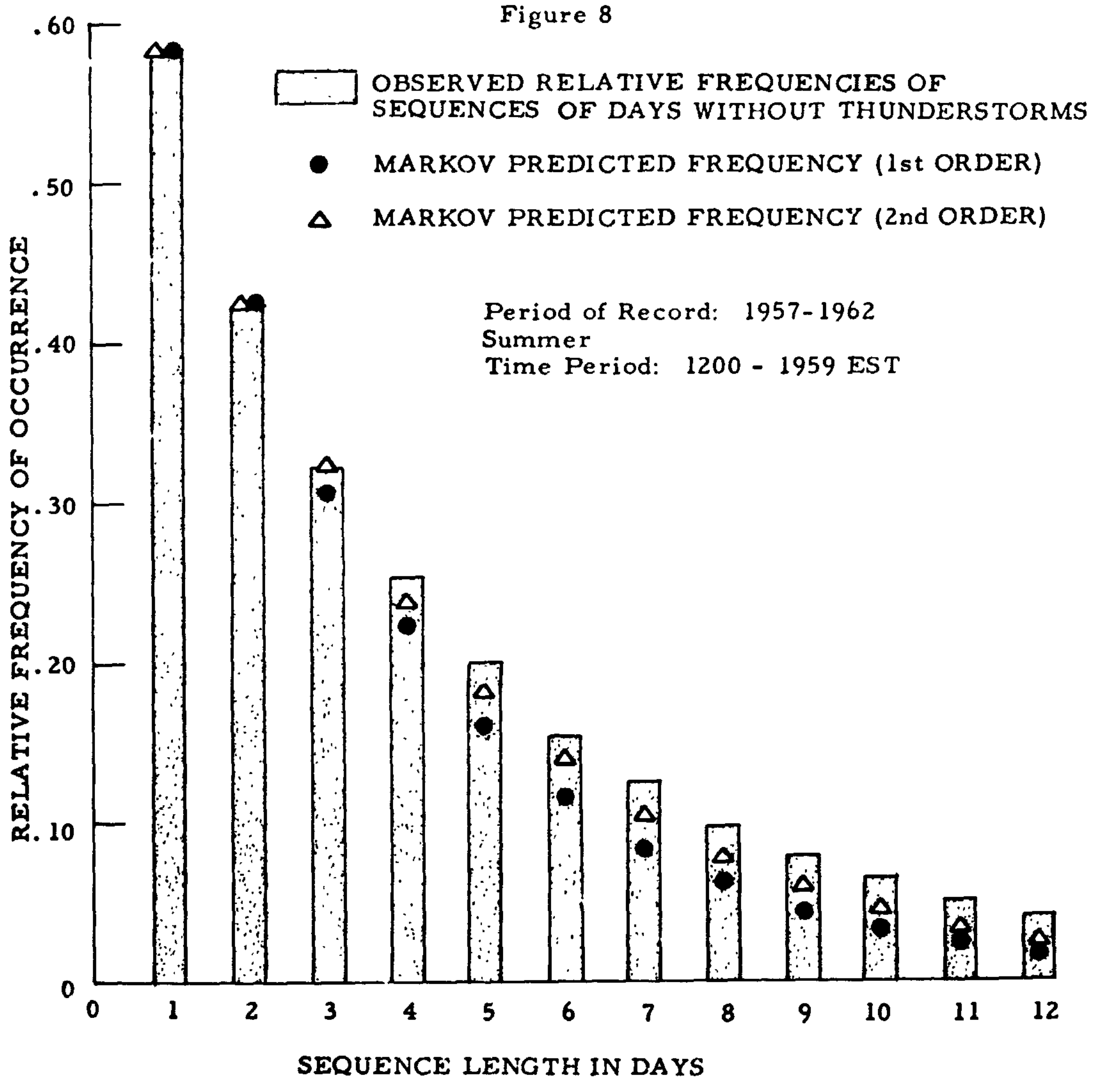

Figure 8. Comparison of the observed and the first and second order Markov predicted relative frequencies of sequences of days during the summer without thunderstorms occurring between 1200 and 1959 EST.

APPENDIX A

TABLE A1.1

Empirical Probability of Thunderstorm

Occurrence by Hour by Month

Cape Kennedy, Florida (1957-1962)

Hour EST	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Ann
00	*	.006	.011	.011	.011	.011	.011	.043	.022	*	*	.005	.011
01	*	.006	.016	*	.011	.011	.011	.032	.028	.011	*	*	.011
02	*	*	.011	*	.005	.022	.011	.027	.011	.016	*	*	.009
03	*	*	.005	*	.005	.017	.005	.016	*	.027	*	*	.006
04	.005	*	.011	*	.005	.006	.005	.011	.006	.016	*	*	.005
05	*	*	.016	.006	.011	.011	.005	.032	.022	.011	*	*	.010
06	*	.006	.011	*	.005	.011	.005	.038	.022	*	*	*	.008
07	*	.006	*	*	*	.006	.005	.016	.033	*	*	*	.006
08	.005	*	.011	*	*	.006	.005	*	.044	*	*	.005	.006
09	.005	*	.016	.006	.011	*	*	.005	.056	.005	*	.005	.009
10	*	.006	.011	.017	.016	.033	.027	.054	.033	.011	*	.005	.018
11	*	.006	.022	.006	.022	.094	.054	.113	.039	.016	*	*	.031
12	*	.006	.027	.011	.016	.128	.134	.151	.067	.027	.006	.005	.048
13	*	.006	.027	.017	.054	.233	.199	.183	.094	.016	.006	*	.070
14	*	*	.027	.022	.075	.222	.258	.204	.100	.022	*	*	.078
15	*	.012	.022	.039	.070	.206	.280	.210	.128	.027	.006	*	.083
16	*	.018	.022	.050	.081	.189	.301	.194	.106	.038	.006	*	.083
17	*	.012	.032	.028	.118	.161	.274	.156	.111	.032	.011	*	.078
18	*	*	.048	.033	.102	.128	.210	.124	.117	.038	.006	*	.067
19	.005	.006	.054	.017	.054	.117	.134	.102	.100	.038	*	*	.052
20	.005	.012	.038	.006	.059	.072	.086	.070	.067	.016	*	*	.036
21	*	.012	.032	.017	.032	.061	.065	.043	.039	.005	*	.005	.026
22	*	.012	.038	.017	.038	.017	.032	.043	.033	.005	*	.005	.020
23	*	.006	.027	.017	.022	.022	.027	.038	.022	.005	*	.005	.016
Avg.	.001	.006	.022	.013	.035	.074	.089	.079	.055	.015	.002	.002	.033
0000-2359	.016	.053	.124	.117	.247	.444	.452	.500	.344	.118	.022	.022	.205

Each hour represents the 60 minutes beginning at the indicated hour; e.g. "00" represents the period 0000-0059 EST.

TABLE AI.2

Empirical Probability of Thunderstorm

Occurrence by Hour by Season

Cape Kennedy, Florida (1957-1962)

	Spring	Summer	Fall	Winter	Ann.
00	.011	.022	.007	.004	.011
01	.009	.018	.013	.002	.011
02	.005	.020	.009	*	.009
03	.004	.013	.009	*	.006
04	.005	.007	.007	.002	.005
05	.011	.016	.011	*	.010
06	.005	.018	.007	.002	.008
07	*	.009	.011	.002	.006
08	.004	.004	.015	.004	.006
09	.011	.002	.020	.004	.009
10	.013	.038	.015	.004	.018
11	.016	.087	.018	.002	.031
12	.018	.138	.033	.004	.048
13	.033	.205	.038	.002	.070
14	.042	.228	.040	*	.078
15	.043	.232	.053	.004	.083
16	.051	.228	.049	.006	.083
17	.060	.197	.051	.004	.078
18	.062	.154	.053	*	.067
19	.042	.118	.046	.004	.052
20	.034	.076	.027	.006	.036
21	.027	.056	.015	.006	.026
22	.031	.031	.013	.006	.020
23	.022	.029	.009	.004	.016
Avg.	.023	.081	.024	.003	.033
0000-2359	.163	.466	.161	.030	.205

TABLE A2.1

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days with thunderstorms during the indicated hours, given that i consecutive days with thunderstorms have just occurred

0000-0359 EST	k											
	1	2	3	4	5	6	7	8	9	10	11	12
June i=0	.033	.011	.006									
1	.333	.167										
2	.500											
July i=0	.022											
August i=0	.059	.005										
1	.091											
Summer i=0	.038	.005	.002									
1	143	.048										
2	.333											
0400-0759 EST												
June i=0	.017	.006										
1	.333											
July i=0	.011											
August i=0	.043	.011										
1	.250											
Summer i=0	.024	.005										
1	.231											

TABLE A2.2

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days with thunderstorms during the indicated hours, given that i consecutive days with thunderstorms have just occurred

0800-1159 EST	k											
	1	2	3	4	5	6	7	8	9	10	11	12
June i=0	.100	.028	.006									
1	.278	.056										
2	.200											
July i=0	.059	.005										
1	.091											
August i=0	.124	.022	.005									
1	.174	.043										
2	.250											
Summer i=0	.094	.018	.004									
1	.192	.038										
2	.200											

TABLE A2.3

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days with thunderstorms during the indicated hours, given that i consecutive days with thunderstorms have just occurred

1200 1559 EST		k											
		1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.333	.156	.078	.044	.022	.006						
	1	.467	.233	.133	.067	.017							
	2	.500	.286	.143	.036								
	3	.571	.286	.071									
	4	.500	.125										
	5	.250											
July	i=0	.366	.215	.134	.086	.048	.022	.011	.005				
	1	.588	.368	.235	.132	.059	.029	.015					
	2	.625	.400	.225	.100	.050	.025						
	3	.640	.360	.160	.080	.040							
	4	.563	.250	.125	.063								
	5	.444	.222	.111									
	6	.500	.250										
	7	.500											
August	i=0	.323	.172	.108	.075	.043	.027	.016	.011	.005			
	1	.533	.333	.233	.133	.083	.050	.033	.017				
	2	.625	.438	.250	.156	.094	.063	.031					
	3	.700	.400	.250	.150	.100	.050						
	4	.571	.357	.214	.143	.071							
	5	.625	.375	.250	.125								
	6	.600	.400	.200									
	7	.667	.333										
	8	.500											
Summer	i=0	.341	.181	.107	.069	.038	.018	.009	.005	.002			
	1	.532	.314	.202	.112	.053	.027	.016	.005				
	2	.590	.380	.210	.100	.050	.030	.010					
	3	.644	.356	.169	.085	.051	.017						
	4	.553	.263	.132	.079	.026							
	5	.476	.238	.143	.048								
	6	.500	.300	.100									
	7	.600	.200										
	8	.333											

TABLE A2.4

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days with thunderstorms during the indicated hours, given that i consecutive days with thunderstorms have just occurred

1600-1959	EST	k: 1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.267	.117	.056	.022	.006							
	1	.438	.208	.083	.021								
	2	.476	.190	.048									
	3	.400	.100										
	4	.250											
July	i=0	.371	.220	.124	.065	.038	.027	.011					
	1	.594	.333	.174	.101	.072	.029						
	2	.561	.293	.171	.122	.049							
	3	.522	.304	.217	.087								
	4	.583	.417	.167									
	5	.714	.286										
	6	.400											
August	i=0	.253	.097	.048	.027	.016	.005						
	1	.383	.191	.106	.064	.021							
	2	.500	.278	.167	.056								
	3	.555	.333	.111									
	4	.600	.200										
	5	.333											
Summer	i=0	.297	.145	.076	.038	.020	.011	.004					
	1	.488	.256	.128	.067	.037	.012						
	2	.525	.263	.138	.075	.025							
	3	.500	.262	.143	.048								
	4	.524	.286	.095									
	5	.545	.182										
	6	.333											

TABLE A2.5

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days with thunderstorms during the indicated hours, given that i consecutive days with thunderstorms have just occurred

2000-2359	EST	k 1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.094	.022	.006									
	1	.235	.059										
	2	.250											
July	i=0	.097	.011										
	1	.111											
August	i=0	.091	.005										
	1	.059											
Summer	i=0	.094	.013	.002									
	1	.135	.019										
	2	.143											

TABLE A3.1

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days with thunderstorms during the indicated hours, given that i consecutive days with thunderstorms have just occurred

		k											
0000-0759	EST	1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.044	.017	.005									
	1	.375	.125										
	2	.333											
July	i=0	.032											
August	i=0	.086	.016										
	1	.188											
Summer	i=0	.054	.011	.002									
	1	.200	.033										
	2	.167											
0400-1159	EST												
June	i=0	.106	.039	.017	.005								
	1	.368	.158	.053									
	2	.429	.143										
	3	.333											
July	i=0	.059	.005										
	1	.091											
August	i=0	.161	.038	.011	.005								
	1	.233	.067	.033									
	2	.286	.143										
	3	.500											
Summer	i=0	.109	.027	.009	.004								
	1	.250	.083	.033									
	2	.333	.133										
	3	.400											

TABLE A3.2

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days with thunderstorms during the indicated hours, given that i consecutive days with thunderstorms have just occurred

0800-1559	EST	k											
		1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.356	.178	.089	.044	.022	.006						
	1	.500	.250	.125	.063	.016							
	2	.500	.250	.125	.031								
	3	.500	.250	.063									
	4	.500	.125										
	5	.250											
July	i=0	.366	.215	.134	.086	.048	.022	.011	.005				
	1	.588	.368	.235	.132	.059	.029	.015					
	2	.625	.400	.225	.100	.050	.025						
	3	.640	.360	.160	.080	.040							
	4	.563	.250	.125	.063								
	5	.444	.222	.111									
	6	.500	.250										
	7	.500											
August	i=0	.349	.194	.118	.075	.043	.027	.016	.011	.005			
	1	.554	.338	.215	.123	.077	.046	.031	.015				
	2	.611	.389	.222	.139	.083	.056	.028					
	3	.636	.364	.227	.136	.091	.045						
	4	.571	.357	.214	.143	.071							
	5	.625	.375	.250	.125								
	6	.600	.400	.200									
	7	.667	.333										
	8	.500											
Summer	i=0	.357	.196	.114	.069	.038	.018	.009	.005	.002			
	1	.548	.320	.193	.107	.051	.025	.015	.005				
	2	.583	.352	.194	.093	.046	.028	.009					
	3	.603	.333	.159	.079	.048	.016						
	4	.553	.263	.132	.079	.026							
	5	.476	.238	.143	.048								
	6	.500	.300	.100									
	7	.600	.200										
	8	.333											

TABLE A3.3

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days with thunderstorms during the indicated hours, given that i consecutive days with thunderstorms have just occurred

1200-1959	EST	k: 1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.406	.228	.133	.072	.033	.017	.006					
	1	.562	.329	.178	.082	.041	.014						
	2	.585	.317	.146	.073	.024							
	3	.542	.250	.125	.042								
	4	.462	.231	.077									
	5	.500	.167										
	6	.333											
July	i=0	.441	.312	.226	.161	.113	.081	.054	.038	.022	.016	.011	.005
	1	.707	.512	.366	.256	.183	.122	.085	.049	.037	.024	.012	
	2	.724	.517	.362	.259	.172	.121	.069	.052	.034	.017		
	3	.714	.500	.357	.238	.167	.095	.071	.048	.024			
	4	.700	.500	.333	.233	.133	.100	.067	.033				
	5	.714	.476	.333	.190	.143	.095	.048					
	6	.667	.467	.267	.200	.133	.067						
	7	.700	.400	.300	.200	.100							
	8	.571	.429	.286	.143								
	9	.750	.500	.250									
	10	.667	.333										
	11	.500											
August	i=0	.414	.237	.140	.091	.059	.038	.022	.016	.011	.005		
	1	.571	.338	.221	.143	.091	.052	.039	.026	.013			
	2	.591	.386	.250	.159	.091	.068	.045	.023				
	3	.654	.423	.269	.154	.115	.077	.038					
	4	.647	.412	.235	.176	.118	.059						
	5	.636	.364	.273	.182	.091							
	6	.571	.429	.286	.143								
	7	.750	.500	.250									
	8	.667	.333										
	9	.500											
Summer	i=0	.420	.259	.167	.109	.069	.045	.027	.018	.011	.007	.004	.002
	1	.616	.397	.259	.164	.108	.065	.043	.026	.017	.009	.004	
	2	.643	.420	.266	.175	.105	.070	.042	.028	.014	.007		
	3	.652	.413	.272	.163	.109	.065	.043	.022	.011			
	4	.633	.417	.250	.167	.100	.067	.033	.017				
	5	.658	.395	.263	.158	.105	.053	.026					
	6	.600	.400	.240	.160	.080	.040						
	7	.667	.400	.267	.133	.067							
	8	.600	.400	.200	.100								
	9	.667	.333	.167									
	10	.500	.250										
	11	.500											

TABLE A3.4

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days with thunderstorms during the indicated hours, given that i consecutive days with thunderstorms have just occurred

1600-2359 EST		k											
		1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.283	.133	.067	.022	.005							
	1	.471	.235	.078	.020								
	2	.500	.167	.042									
	3	.333	.083										
	4	.250											
July	i=0	.376	.167	.124	.065	.038	.027	.011					
	1	.443	.329	.171	.100	.071	.029						
	2	.742	.387	.226	.161	.065							
	3	.522	.304	.217	.087								
	4	.583	.417	.167									
	5	.714	.286										
	6	.400											
August	i=0	.280	.102	.054	.027	.016	.005						
	1	.365	.192	.096	.058	.019							
	2	.526	.263	.158	.053								
	3	.500	.300	.100									
	4	.600	.200										
	5	.333											
Summer	i=0	.313	.134	.082	.038	.020	.011	.004					
	1	.428	.260	.121	.064	.035	.012						
	2	.608	.284	.149	.081	.027							
	3	.467	.244	.133	.044								
	4	.524	.286	.095									
	5	.545	.182										
	6	.333											

TABLE A3.5

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days with thunderstorms during the indicated hours, given that i consecutive days with thunderstorms have just occurred

0000-2359	EST	k											
		1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.444	.278	.172	.100	.050	.022	.006					
	1	.625	.388	.225	.113	.050	.013						
	2	.620	.360	.180	.080	.020							
	3	.581	.290	.129	.032								
	4	.500	.222	.056									
	5	.444	.111										
	6	.250											
July	i=0	.452	.317	.231	.161	.113	.081	.054	.038	.022	.016	.011	.005
	1	.702	.512	.357	.250	.179	.119	.083	.048	.036	.024	.012	
	2	.729	.508	.356	.254	.169	.119	.068	.051	.034	.017		
	3	.698	.488	.349	.233	.163	.093	.070	.047	.023			
	4	.700	.500	.333	.233	.133	.100	.067	.033				
	5	.714	.476	.333	.190	.143	.095	.048					
	6	.667	.467	.267	.200	.133	.067						
	7	.700	.400	.300	.200	.100							
	8	.571	.429	.286	.143								
	9	.750	.500	.250									
	10	.667	.333										
	11	.500											
August	i=0	.500	.312	.199	.134	.086	.054	.032	.016	.011	.005		
	1	.624	.398	.269	.172	.108	.065	.032	.022	.011			
	2	.638	.431	.276	.172	.103	.052	.034	.017				
	3	.676	.432	.270	.162	.081	.054	.027					
	4	.640	.400	.240	.120	.080	.040						
	5	.625	.375	.188	.125	.063							
	6	.600	.300	.200	.100								
	7	.500	.333	.167									
	8	.667	.333										
	9	.500											
Summer	i=0	.466	.303	.201	.132	.083	.053	.031	.018	.011	.007	.004	.002
	1	.650	.432	.284	.179	.113	.066	.039	.023	.016	.008	.004	
	2	.665	.437	.275	.174	.102	.060	.036	.024	.012	.006		
	3	.658	.414	.261	.153	.090	.054	.036	.018	.009			
	4	.630	.397	.233	.137	.082	.055	.027	.014				
	5	.630	.370	.217	.130	.087	.043	.022					
	6	.586	.345	.207	.138	.069	.034						
	7	.588	.353	.235	.118	.059							
	8	.600	.400	.200	.100								
	9	.667	.333	.167									
	10	.500	.250										
	11	.500											

TABLE A4.1

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

0000-0359 EST		k											
		1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.967	.950	.933	.917	.895	.872	.850	.828	.806	.783	.761	.739
	1	.983	.965	.948	.925	.902	.879	.856	.833	.810	.787	.764	.741
	2	.982	.965	.942	.918	.895	.871	.848	.825	.801	.778	.754	.731
	3	.982	.958	.934	.911	.887	.863	.839	.815	.792	.768	.744	.720
	4	.976	.952	.927	.903	.879	.855	.830	.806	.782	.758	.733	
	5	.975	.950	.925	.901	.876	.851	.826	.801	.776	.752		
	6	.974	.949	.924	.898	.873	.847	.822	.796	.771			
	7	.974	.948	.922	.895	.869	.843	.817	.791				
	8	.973	.946	.919	.893	.866	.839	.812					
	9	.972	.945	.917	.890	.862	.835						
	10	.972	.943	.915	.887	.858							
	11	.971	.942	.912	.883								
	12	.970	.940	.910									
July	i=0	.978	.952	.925	.898	.876	.855	.833	.812	.785	.758	.731	.704
	1	.973	.945	.918	.896	.874	.852	.830	.802	.775	.747	.720	.692
	2	.972	.944	.921	.898	.876	.853	.825	.797	.768	.740	.712	.689
	3	.971	.948	.924	.901	.878	.849	.820	.791	.762	.733	.709	.686
	4	.976	.952	.928	.904	.874	.844	.814	.784	.754	.731	.707	
	5	.975	.951	.926	.896	.865	.834	.804	.773	.748	.724		
	6	.975	.950	.918	.887	.855	.824	.792	.767	.742			
	7	.974	.942	.910	.877	.845	.813	.787	.761				
	8	.967	.934	.901	.868	.834	.808	.782					
	9	.966	.931	.897	.863	.836	.808						
	10	.965	.929	.894	.865	.837							
	11	.963	.926	.897	.868								
	12	.962	.931	.901									

TABLE A4.2

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without

thunderstorms during the indicated hours, given that

i consecutive days without thunderstorms have just occurred.

0000-0359 EST	k											
	1	2	3	4	5	6	7	8	9	10	11	12
August i=0	.941	.892	.844	.796	.747	.699	.650	.613	.575	.538	.500	.473
1	.949	.897	.846	.794	.743	.691	.651	.611	.571	.531	.503	.474
2	.946	.892	.837	.783	.729	.687	.645	.602	.560	.530	.500	.470
3	.943	.885	.828	.771	.726	.681	.637	.592	.560	.529	.497	.471
4	.939	.878	.818	.770	.723	.676	.628	.595	.561	.527	.500	
5	.935	.870	.820	.770	.719	.669	.633	.597	.561	.532		
6	.931	.877	.823	.769	.715	.677	.638	.600	.569			
7	.942	.884	.826	.769	.727	.686	.645	.612				
8	.939	.877	.816	.772	.728	.684	.649					
9	.935	.869	.822	.776	.729	.692						
10	.930	.880	.830	.780	.740							
11	.946	.892	.839	.796								
12	.943	.886	.841									
Summer i=0	.962	.931	.901	.870	.839	.808	.777	.750	.721	.692	.663	.638
1	.968	.936	.904	.872	.840	.808	.780	.749	.719	.689	.663	.636
2	.967	.934	.901	.868	.835	.806	.775	.743	.712	.685	.658	.632
3	.966	.932	.897	.863	.833	.801	.769	.736	.708	.680	.654	.630
4	.965	.929	.894	.862	.829	.796	.763	.733	.704	.677	.652	
5	.963	.927	.894	.860	.825	.790	.760	.730	.702	.676		
6	.962	.928	.892	.857	.821	.789	.758	.729	.702			
7	.965	.928	.890	.853	.821	.788	.758	.730				
8	.961	.923	.884	.850	.816	.785	.756					
9	.960	.920	.884	.849	.817	.786						
10	.958	.921	.885	.851	.819							
11	.962	.923	.888	.855								
12	.960	.923	.889									

TABLE A4.3

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

0400-0759	EST	k											
		1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.983	.967	.950	.933	.917	.900	.883	.867	.850	.833	.817	.800
	1	.983	.966	.949	.932	.915	.898	.881	.864	.847	.831	.814	.791
	2	.983	.966	.948	.931	.914	.897	.879	.862	.845	.828	.805	.782
	3	.982	.965	.947	.930	.912	.895	.877	.860	.842	.819	.795	.772
	4	.982	.964	.946	.929	.911	.893	.875	.857	.833	.810	.786	
	5	.982	.964	.945	.927	.909	.891	.873	.848	.824	.800		
	6	.981	.963	.944	.926	.907	.889	.864	.840	.815			
	7	.981	.962	.943	.925	.906	.881	.855	.830				
	8	.981	.962	.942	.923	.84[illegible]	.872	.846					
	9	.980	.961	.941	.915	.889	.863						
	10	.980	.960	.933	.907	.880							
	11	.980	.952	.925	.898								
	12	.972	.944	.917									
July	i=0	.989	.984	.978	.973	.968	.957	.946	.930	.914	.898	.882	.866
	1	.995	.989	.984	.978	.967	.957	.940	.924	.908	.891	.875	.859
	2	.995	.989	.984	.973	.962	.945	.929	.913	.896	.880	.863	.847
	3	.995	.989	.978	.967	.951	.934	.918	.901	.885	.868	.852	.835
	4	.994	.983	.972	.956	.939	.923	.906	.890	.873	.856	.840	
	5	.989	.978	.961	.944	.928	.911	.894	.878	.861	.844		
	6	.989	.972	.955	.938	.921	.904	.888	.871	.854			
	7	.983	.966	.949	.932	.915	.898	.881	.864				
	8	.983	.965	.948	.931	.913	.896	.879					
	9	.982	.965	.947	.929	.912	.894						
	10	.982	.964	.946	.928	.910							
	11	.982	.963	.945	.927								
	12	.981	.963	.944									

TABLE A4.4

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days withou
thunderstorms during the indicated hours, given that
i consecutive days without thunderstorms have just occurred.

0400-0759 EST		k											
		1	2	3	4	5	6	7	8	9	10	11	12
August	i=0	.957	.919	.882	.849	.817	.785	.753	.726	.699	.667	.634	.602
	1	.961	.921	.888	.854	.820	.787	.758	.730	.697	.663	.629	.596
	2	.959	.924	.889	.854	.819	.789	.760	.725	.690	.655	.620	.585
	3	.963	.927	.890	.854	.823	.793	.756	.720	.683	.646	.610	.567
	4	.962	.924	.886	.854	.823	.785	.747	.709	.671	.633	.589	
	5	.961	.921	.888	.855	.816	.776	.737	.697	.658	.612		
	6	.959	.925	.890	.849	.808	.767	.726	.685	.637			
	7	.964	.929	.886	.843	.800	.757	.714	.664				
	8	.963	.919	.874	.830	.785	.741	.689					
	9	.954	.908	.862	.815	.769	.715						
	10	.952	.903	.855	.806	.750							
	11	.949	.898	.847	.788								
	12	.946	.893	.830									
Summer	i=0	.976	.957	.937	.918	.900	.880	.861	.841	.821	.799	.777	.755
	1	.980	.959	.941	.922	.902	.881	.861	.840	.818	.796	.774	.750
	2	.979	.960	.941	.920	.900	.879	.858	.835	.812	.790	.765	.741
	3	.981	.961	.940	.919	.897	.876	.853	.830	.807	.781	.756	.729
	4	.980	.959	.937	.915	.893	.870	.846	.822	.797	.771	.744	
	5	.978	.956	.934	.911	.887	.863	.839	.813	.787	.759		
	6	.977	.955	.932	.907	.883	.858	.831	.805	.776			
	7	.977	.954	.928	.903	.878	.851	.823	.794				
	8	.976	.950	.925	.899	.871	.843	.813					
	9	.974	.947	.921	.892	.863	.832						
	10	.973	.946	.916	.887	.855							
	11	.972	.942	.911	.879								
	12	.969	.938	.904									

TABLE A4.5

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

0800-1159 EST		k											
		1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.900	.822	.761	.694	.628	.561	.511	.478	.444	.417	.389	.361
	1	.914	.846	.772	.698	.623	.568	.531	.494	.463	.432	.401	.364
	2	.926	.845	.764	.682	.622	.581	.541	.507	.473	.439	.399	.358
	3	.912	.825	.737	.672	.628	.584	.547	.511	.474	.431	.387	.343
	4	.904	.808	.736	.688	.640	.600	.560	.520	.472	.424	.376	
	5	.894	.814	.761	.708	.664	.619	.575	.522	.469	.416		
	6	.911	.851	.792	.743	.693	.644	.584	.525	.465			
	7	.935	.870	.815	.761	.707	.641	.576	.511				
	8	.930	.872	.814	.756	.686	.616	.547					
	9	.938	.875	.813	.738	.663	.588						
	10	.933	.867	.787	.707	.627							
	11	.929	.843	.757	.671								
	12	.908	.815	.723									
July	i=0	.941	.892	.844	.806	.769	.726	.677	.624	.570	.527	.484	.441
	1	[illegible]	.897	.857	.817	.771	.720	.663	.606	.560	.514	.469	.429
	2	.946	.904	.861	.813	.759	.699	.639	.590	.542	.494	.452	.416
	3	.955	.911	.860	.803	.739	.675	.624	.573	.522	.478	.439	.401
	4	.953	.900	.840	.773	.707	.653	.600	.547	.500	.460	.420	
	5	.944	.881	.811	.741	.685	.629	.573	.524	.483	.441		
	6	.933	.859	.785	.726	.667	.607	.556	.511	.467			
	7	.921	.841	.778	.714	.651	.595	.548	.500				
	8	.914	.845	.776	.707	.647	.595	.543					
	9	.925	.849	.774	.708	.651	.594						
	10	.918	.837	.765	.704	.643							
	11	.911	.833	.767	.700								
	12	.915	.841	.768									

TABLE A4.6

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

0800-1159 EST		k											
		1	2	3	4	5	6	7	8	9	10	11	12
August	i=0	.876	.774	.683	.608	.527	.457	.403	.355	.312	.274	.242	.210
	1	.883	.779	.693	.601	.521	.460	.405	.356	.313	.276	.239	.209
	2	.882	.785	.681	.590	.521	.458	.403	.354	.312	.271	.236	.208
	3	.890	.772	.669	.591	.520	.457	.402	.354	.307	.268	.236	.213
	4	.867	.752	.664	.584	.513	.451	.398	.345	.301	.265	.239	
	5	.867	.765	.673	.592	.520	.459	.398	.347	.306	.276		
	6	.882	.776	.682	.600	.529	.459	.400	.353	.318			
	7	.880	.773	.680	.600	.520	.453	.400	.360				
	8	.879	.773	.682	.591	.515	.455	.409					
	9	.879	.776	.672	.586	.517	.466						
	10	.882	.765	.667	.588	.529							
	11	.867	.756	.657	.600								
	12	.872	.769	.692									
Summer	i=0	.906	.830	.763	.703	.641	.582	.531	.486	.442	.406	.371	.337
	1	.916	.842	.776	.708	.642	.586	.536	.488	.448	.410	.372	.336
	2	.919	.847	.773	.701	.640	.585	.533	.489	.448	.406	.367	.332
	3	.922	.841	.762	.696	.637	.580	.532	.487	.442	.399	.361	.325
	4	.912	.827	.755	.691	.629	.577	.528	.479	.433	.392	.353	
	5	.907	.828	.757	.689	.633	.579	.525	.475	.429	.387		
	6	.913	.835	.760	.698	.639	.579	.523	.474	.427			
	7	.915	.833	.765	.700	.635	.573	.519	.468				
	8	.910	.836	.765	.694	.627	.567	.511					
	9	.918	.840	.762	.689	.623	.561						
	10	.915	.830	.750	.679	.612							
	11	.907	.820	.741	.668								
	12	.903	.817	.737									

TABLE A4.7

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

1200-1559	EST	k = 1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.667	.494	.372	.294	.222	.178	.144	.117	.094	.072	.056	.050
	1	.742	.558	.442	.333	.267	.217	.175	.142	.108	.083	.075	.067
	2	.753	.596	.449	.360	.292	.236	.191	.146	.112	.101	.090	.079
	3	.791	.597	.478	.388	.313	.254	.194	.149	.134	.119	.104	.090
	4	.755	.604	.491	.396	.321	.245	.189	.170	.151	.132	.113	
	5	.800	.650	.525	.425	.325	.250	.225	.200	.175	.150		
	6	.813	.656	.531	.406	.313	.281	.250	.219	.188			
	7	.808	.654	.500	.385	.346	.308	.269	.231				
	8	.810	.619	.476	.429	[illegible]	[illegible]	.286					
	9	.765	.588	.529	.471	.412	[illegible]						
	10	.769	.692	.615	.538	.462							
	11	.900	.800	.700	.600								
	12	.889	.778	.667									
July	i=0	.634	.484	.371	.301	.242	.194	.172	.151	.140	.129	.118	.108
	1	.763	.585	.475	.381	.305	.271	.237	.220	.203	.186	.169	.153
	2	.767	.622	.500	.400	.356	.311	.289	.267	.244	.222	.200	.178
	3	.812	.652	.522	.464	.406	.377	.348	.319	.290	.261	.232	.188
	4	.804	.643	.571	.500	.464	.429	.393	.357	.321	.286	.232	
	5	.800	.711	.622	.578	.533	.489	.444	.400	.356	.289		
	6	.889	.778	.722	.667	.611	.556	.500	.444	.361			
	7	.875	.813	.750	.688	.625	.563	.500	.406				
	8	.929	.857	.786	.714	.643	.571	.464					
	9	.923	.846	.769	.692	.615	.500						
	10	.917	.833	.750	.667	.542							
	11	.909	.818	.727	.591								
	12	.900	.800	.600									

TABLE A4.8

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

1200-1559 EST		k											
		1	2	3	4	5	6	7	8	9	10	11	12
August	i=0	.677	.538	.441	.360	.285	.220	.172	.129	.097	.070	.054	.038
	1	.793	.651	.532	.421	.325	.254	.190	.143	.103	.079	.056	032
	2	.820	.670	.530	.410	.320	.240	.180	.130	.100	.070	.040	.010
	3	.817	.646	.500	.390	.293	.220	.159	.122	.085	.049	.012	
	4	.791	.612	.478	.358	.269	.194	.149	.104	.060	.015		
	5	.774	.604	.453	.340	.245	.189	.132	.073	.019			
	6	.780	.585	.439	.317	.244	.171	.098	.024				
	7	.750	.563	.406	.313	.219	.125	.031					
	8	.750	.542	.417	.292	.167	.042						
	9	.722	.556	.389	.222	.056							
	10	.769	.538	.308	.077								
	11	.700	.400	.100									
	12	.571	.143										
Summer	i=0	.659	.505	.395	.319	.250	.197	.163	.132	.111	.091	.076	.065
	1	.766	.599	.484	.379	.299	.247	.201	.168	.137	.115	.099	.082
	2	.781	.631	.495	.391	.323	.262	.219	.179	.151	.129	.108	.086
	3	.807	.633	.500	.413	.335	.280	.229	.193	.165	.138	.110	.087
	4	.784	.619	.511	.415	.347	.284	.239	.205	.170	.136	.108	
	5	.790	.652	.529	.442	.362	.304	.261	.217	.174	.138		
	6	.826	.670	.560	.459	.385	.330	.275	.220	.174			
	7	.811	.678	.556	.467	.400	.333	.267	.211				
	8	.836	.685	.575	.493	.411	.329	.260					
	9	.820	.689	.590	.492	.393	.311						
	10	.840	.720	.600	.480	.380							
	11	.857	.714	.571	.452								
	12	.833	.667	.528									

TABLE A4.9

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

1600-1959	EST	k											
		1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.733	.589	.489	.406	.333	.267	.217	.172	.133	.106	.083	.067
	1	.803	.667	.553	.455	.364	.295	.235	.182	.144	.114	.091	.076
	2	.830	.689	.566	.453	.368	.292	.226	.179	.142	.113	.094	.075
	3	.830	.682	.545	.443	.352	.273	.216	.170	.136	.114	.091	.068
	4	.822	.658	.534	.425	.329	.260	.205	.164	.137	.110	.082	
	5	.800	.650	.517	.400	.317	.250	.200	.167	.133	.100		
	6	.813	.646	.500	.396	.313	.250	.208	.167	.125			
	7	.795	.615	.487	.385	.308	.256	.205	.154				
	8	.774	.613	.484	.387	.323	.258	.194					
	9	.792	.625	.500	.417	.333	.250						
	10	.789	.632	.526	.421	.316							
	11	.800	.667	.533	.400								
	12	.833	.667	.500									
July	i=0	.629	.468	.366	.290	.237	.204	.172	.145	.129	.118	.108	.097
	1	.744	.581	.462	.376	.325	.274	.231	.205	.188	.171	.154	.137
	2	.782	.621	.506	.437	.368	.310	.276	.253	.230	.207	.184	.161
	3	.794	.647	.559	.471	.397	.353	.324	.294	.265	.235	.206	.176
	4	.815	.704	.593	.500	.444	.407	.370	.333	.296	.259	.222	
	5	.864	.727	.614	.545	.500	.455	.409	.364	.318	.273		
	6	.842	.711	.632	.579	.526	.474	.421	.368	.316			
		.844	.750	.688	.625	.563	.500	.438	.375				
		.889	.815	.741	.667	.593	.519	.444					
	9	.917	.833	.750	.667	.583	.500						
	10	.909	.818	.727	.636	.545							
	11	.900	.800	.700	.600								
	12	.889	.778	.667									

TABLE A4.10

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

1600-1959 EST		k											
		1	2	3	4	5	6	7	8	9	10	11	12
August	i=0	.747	.602	.484	.398	.317	.242	.188	.156	.134	.118	.102	.086
	1	.806	.647	.532	.424	.324	.252	.209	.180	.158	.137	.115	
	2	.804	.661	.527	.402	.313	.259	.223	.196	.170	.143		
	3	.822	.656	.500	.389	.322	.278	.244	.211	.178			
	4	.797	.608	.473	.392	.338	.297	.257	.216				
	5	.763	.593	.492	.424	.373	.322	.271					
	6	.778	.644	.556	.489	.422	.356						
	7	.829	.714	.629	.543	.457							
	8	.862	.759	.655	.552								
	9	.880	.760	.640									
	10	.864	.727										
	11	.842											
Summer	i=0	.703	.553	.446	.364	.295	.237	.192	.158	.132	.114	.098	.083
	1	.786	.634	.518	.420	.338	.273	.224	.188	.162	.139	.119	.103
	2	.807	.659	.534	.430	.348	.285	.239	.207	.177	.151	.131	.111
	3	.817	.663	.533	.431	.354	.297	.256	.220	.187	.163	.138	.110
	4	.811	.652	.527	.433	.363	.313	.269	.229	.199	.169	.134	
	5	.804	.650	.534	.448	.387	.331	.282	.245	.209	.166		
	6	.809	.664	.557	.481	.412	.351	.305	.260	.206			
	7	.821	.689	.594	.509	.434	.377	.321	.255				
	8	.839	.724	.621	.529	.460	.391	.310					
	9	.863	.740	.630	.548	.466	.370						
	10	.857	.730	.635	.540	.429							
	11	.852	.741	.630	.500								
	12	.870	.739	.587									

TABLE A4.11

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

2000-2359 EST		k 1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.906	.828	.778	.722	.672	.622	.583	.533	.483	.439	.400	.361
	1	.914	.859	.798	.742	.687	.644	.589	.534	.485	.442	.399	.362
	2	.940	.872	.812	.752	.705	.644	.584	.530	.483	.436	.396	.362
	3	.929	.864	.800	.750	.686	.621	.564	.514	.464	.421	.386	.357
	4	.931	.862	.808	.738	.669	.608	.554	.500	.454	.415	.385	
	5	.926	.868	.793	.719	.653	.595	.537	.488	.446	.413		
	6	.938	.857	.777	.705	.643	.580	.527	.482	.446			
	7	.914	.829	.752	.686	.619	.562	.514	.476				
	8	.906	.823	.750	.677	.615	.563	.521					
	9	.908	.828	.747	.678	.621	.575						
	10	.911	.823	.747	.684	.633							
	11	.903	.819	.750	.694								
	12	.908	.831	.769									
July	i=0	.903	.817	.742	.683	.618	.554	.495	.446	.414	.382	.355	.333
	1	.905	.821	.756	.685	.613	.548	.494	.458	.423	.393	.369	.345
	2	.908	.836	.757	.678	.605	.546	.507	.467	.434	.408	.382	.362
	3	.920	.833	.746	.667	.601	.558	.514	.478	.449	.420	.399	.377
	4	.906	.811	.724	.654	.606	.559	.520	.488	.457	.433	.409	
	5	.896	.800	.722	.670	.617	.574	.539	.504	.478	.452		
	6	.893	.806	.748	.689	.641	.602	.563	.534	.505			
	7	.902	.837	.772	.717	.674	.630	.598	.565				
	8	.928	.855	.795	.747	.699	.663	.627					
	9	.922	.857	.805	.753	.714	.675						
	10	.930	.873	.817	.775	.732							
	11	.939	.879	.833	.788								
	12	.935	.887	.839									

TABLE A4.12

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

2000-2359 EST		k											
		1	2	3	4	5	6	7	8	9	10	11	12
August	i=0	.909	.823	.742	.672	.602	.538	.473	.430	.387	.344	.296	.269
	1	.905	.817	.740	.663	.592	.521	.473	.426	.379	.325	.296	.260
	2	.902	.817	.732	.654	.575	.523	.471	.418	.359	.327	.288	.248
	3	.906	.812	.725	.638	.580	.522	.464	.399	.362	.319	.275	.232
	4	.896	.800	.704	.640	.576	.512	.440	.400	.352	.304	.256	
	5	.893	.786	.714	.643	.571	.491	.446	.393	.339	.286		
	6	.880	.800	.720	.640	.550	.500	.440	.380	.320			
	7	.909	.818	.727	.625	.568	.500	.432	.364				
	8	.900	.800	.688	.625	.550	.475	.400					
	9	.889	.764	.694	.611	.528	.444						
	10	.859	.781	.688	.594	.500							
	11	.909	.800	.691	.582								
	12	.880	.760	.640									
Summer	i=0	.905	.822	.754	.692	.630	.571	.516	.469	.428	.388	.350	.321
	1	.908	.832	.764	.696	.630	.570	.518	.472	.428	.386	.354	.322
	2	.916	.841	.767	.694	.628	.570	.520	.471	.425	.390	.355	.324
	3	.918	.837	.757	.685	.623	.567	.514	.464	.425	.387	.353	.322
	4	.911	.825	.746	.678	.618	.560	.505	.463	.421	.385	.351	
	5	.905	.819	.744	.678	.615	.555	.509	.463	.422	.385		
	6	.905	.822	.749	.679	.613	.562	.511	.467	.317			
	7	.909	.828	.751	.677	.621	.565	.516	.470				
	8	.911	.826	.745	.683	.622	.568	.517					
	9	.907	.818	.750	.682	.623	.568						
	10	.902	.827	.752	.687	.626							
	11	.917	.834	.762	.694								
	12	.910	.831	.757									

TABLE A5.1

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

0000-0759	EST	k											
		1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.956	.928	.900	.872	.839	.806	.772	.739	.711	.683	.656	.628
	1	.971	.942	.913	.878	.843	.808	.773	.744	.715	.686	.657	.622
	2	.970	.940	.904	.868	.832	.796	.766	.737	.707	.677	.641	.605
	3	.969	.932	.895	.858	.821	.790	.759	.728	.698	.660	.623	.593
	4	.962	.924	.885	.847	.815	.783	.752	.720	.682	.643	.611	
	5	.960	.921	.881	.848	.815	.781	.748	.709	.669	.636		
	6	.959	.917	.883	.848	.814	.779	.738	.697	.662			
	7	.957	.921	.885	.849	.813	.770	.727	.691				
	8	.962	.925	.887	.850	.805	.759	.722					
	9	.961	.922	.883	.836	.789	.750						
	10	.959	.919	.870	.821	.780							
	11	.958	.907	.856	.814								
	12	.947	.894	.850									
July	i=0	.968	.935	.903	.871	.844	.812	.780	.747	.710	.672	.634	.597
	1	.967	.933	.900	.872	.839	.806	.772	.733	.694	.656	.617	.589
	2	.966	.931	.902	.868	.833	.799	.759	.718	.678	.638	.609	.592
	3	.964	.935	.899	.863	.827	.786	.744	.702	.661	.631	.613	.595
	4	.969	.932	.895	.858	.815	.772	.728	.685	.654	.636	.617	
	5	.962	.924	.885	.841	.796	.752	.707	.675	.656	.637		
	6	.960	.921	.874	.828	.781	.735	.702	.682	.662			
	7	.959	.910	.862	.814	.766	.731	.710	.690				
	8	.950	.899	.849	.799	.763	.741	.719					
	9	.947	.894	.841	.803	.780	.758						
	10	.944	.888	.848	.824	.800							
	11	.941	.898	.873	.847								
	12	.955	.928	.901									

TABLE A5.2

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred

0000-0759 EST	k											
	1	2	3	4	5	6	7	8	9	10	11	12
August i=0	.914	.844	.774	.710	.645	.581	.516	.473	.430	.382	.333	.296
1	.924	.847	.776	.706	.635	.565	.518	.471	.418	.365	.324	.282
2	.917	.841	.764	.688	.611	.561	.510	.452	.395	.350	.306	.261
3	.917	.833	.750	.667	.611	.556	.493	.431	.382	.333	.285	.243
4	.909	.818	.727	.667	.606	.538	.470	.417	.364	.311	.265	
5	.900	.800	.733	.667	.592	.517	.458	.400	.342	.292		
6	.889	.815	.741	.657	.574	.509	.444	.380	.324			
7	.917	.833	.740	.646	.573	.500	.427	.365				
8	.909	.807	.705	.625	.545	.466	.398					
9	.888	.775	.688	.600	.513	.438						
10	.873	.775	.676	.577	.493							
11	.887	.774	.661	.565								
12	.873	.745	.636									
Summer i=0	.946	.902	.859	.817	.775	.732	.688	.652	.616	.578	.540	.505
1	.954	.908	.864	.820	.774	.728	.690	.651	.611	.571	.534	.500
2	.952	.906	.859	.811	.763	.723	.683	.641	.598	.560	.524	.492
3	.951	.903	.852	.802	.759	.717	.673	.629	.589	.551	.517	487
4	.949	.896	.843	.798	.754	.707	.661	.619	.579	.543	.512	
5	.944	.888	.841	.794	.745	.696	.652	.610	.572	.540		
6	.941	.891	.842	.790	.738	.691	.646	.606	.572			
7	.947	.895	.839	.784	.734	.687	.645	.608				
8	.944	.886	.828	.775	.725	.681	.642					
9	.938	.876	.821	.768	.721	.679						
10	.934	.875	.818	.768	.724							
11	.936	.876	.822	.775								
12	.935	.878	.828									

TABLE A5.3

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

0400-1159 EST		k											
		1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.894	.822	.761	.694	.628	.561	.511	.478	.450	.422	.394	.367
	1	.919	.851	.776	.702	.627	.571	.534	.503	.472	.441	.410	.379
	2	.926	.845	.764	.682	.622	.581	.547	.514	.480	.446	.412	.372
	3	.912	.825	.737	.672	.628	.591	.555	.518	.482	.445	.401	.365
	4	.904	.808	.736	.688	.648	.608	.568	.528	.488	.440	.400	
	5	.894	.814	.761	.717	.673	.628	.584	.540	.487	.442		
	6	.911	.851	.802	.752	.703	.653	.604	.545	.495			
	7	.935	.880	.826	.772	.717	.663	.598	.543				
	8	.942	.884	.826	.767	.709	.640	.582					
	9	.938	.877	.815	.753	.679	.617						
	10	.934	.868	.803	.724	.658							
	11	.930	.859	.775	.704								
	12	.924	.833	.758									
July	i=0	.941	.892	.844	.806	.769	.720	.667	.608	.548	.500	.452	.403
	1	.949	.897	.857	.817	.766	.709	.646	.583	.531	.480	.42[illegible]	.383
	2	.946	.904	.861	.807	.747	.681	.614	.560	.506	.452	.404	.361
	3	.955	.911	.853	.790	.720	.650	.592	.535	.478	.427	.382	.338
	4	.953	.893	.827	.753	.680	.620	.560	.500	.447	.400	.353	
	5	.937	.867	.790	.713	.650	.587	.524	.469	.420	.371		
	6	.925	.843	.761	.694	.627	.560	.500	.448	.396			
	7	.911	.823	.750	.677	.605	.540	.484	.427				
	8	.903	.823	.743	.664	.593	.531	.469					
	9	.912	.824	.735	.657	.588	.520						
	10	.903	.806	.720	.645	.570							
	11	.893	.798	.714	.631								
	12	.893	.800	.707									

TABLE A5.4

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred

0400-1159 EST	k											
	1	2	3	4	5	6	7	8	9	10	11	12
August i=0	.839	.710	.602	.516	.430	.366	.317	.274	.237	.204	.177	.151
1	.846	.718	.615	.513	.436	.378	.327	.282	.244	.212	.179	.154
2	.848	.727	.606	.515	.447	.386	.333	.288	.250	.212	.182	.159
3	.857	.714	.607	.527	.455	.393	.339	.295	.250	.214	.188	.161
4	.833	.708	.615	.531	.458	.396	.344	.292	.250	.219	.188	
5	.850	.738	.638	.550	.475	.413	.350	.300	.263	.225		
6	.868	.750	.647	.559	.485	.412	.353	.309	.265			
7	.864	.746	.644	.559	.475	.407	.356	.305				
8	.863	.745	.647	.549	.471	.412	.353					
9	.864	.750	.636	.545	.477	.409						
10	.868	.737	.632	.553	.474							
11	.848	.727	.636	.545								
12	.857	.750	.643									
Summer i=0	.891	.808	.736	.672	.609	.549	.498	.453	.411	.375	.341	.306
1	.906	.825	.754	.683	.616	.559	.508	.461	.421	.382	.343	.309
2	.910	.832	.753	.679	.617	.561	.509	.464	.422	.379	.341	.305
3	.914	.828	.746	.677	.616	.559	.510	.463	.416	.374	.335	.298
4	.906	.817	.741	.674	.612	.558	.507	.456	.410	.367	.326	
5	.902	.818	.744	.676	.616	.560	.503	.452	.405	.360		
6	.908	.825	.749	.683	.620	.558	.502	.449	.399			
7	.909	.825	.753	.684	.615	.553	.495	.440				
8	.908	.828	.752	.676	.608	.544	.484					
9	.912	.828	.744	.670	.599	.533						
10	.908	.816	.734	.657	.585							
11	.899	.809	.723	.644								
12	.899	.805	.716									

TABLE A5.5

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred

0800-1559	EST	k											
		1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.644	.461	.350	.272	.200	.156	.122	.100	.083	.067	.056	.050
	1	.716	.543	.422	.310	.241	.190	.155	.129	.103	.086	.078	.069
	2	.759	.590	.434	.337	.265	.217	.181	.145	.120	.108	.096	.084
	3	.778	.571	.444	.349	.286	.238	.190	.159	.143	.127	.111	.095
	4	.735	.571	.449	.367	.306	.245	.204	.184	.163	.143	.122	
	5	.778	.611	.500	.417	.333	.278	.250	.222	.194	.167		
	6	.786	.643	.536	.429	.357	.321	.286	.250	.214			
	7	.818	.682	.545	.455	.409	.364	.318	.273				
	8	.833	.667	.556	.500	.444	.389	.333					
	9	.800	.667	.600	.533	.467	.400						
	10	.833	.750	.667	.583	.500							
	11	.900	.800	.700	.600								
	12	.889	.778	.667									
July	i=0	.634	.484	.371	.301	.242	.194	.172	.151	.140	.124	.108	.091
	1	.763	.585	.475	.381	.305	.271	.237	.220	.195	.169	.144	.119
	2	.767	.622	.500	.400	.356	.311	.289	.256	.222	.189	.156	.133
	3	.812	.652	.522	.464	.406	.377	.333	.290	.246	.203	.174	.145
	4	.804	.643	.571	.500	.464	.411	.357	.304	.250	.214	.179	
	5	.800	.711	.622	.578	.511	.444	.378	.311	.267	.222		
	6	.889	.778	.722	.639	.556	.472	.389	.333	.278			
	7	.875	.813	.719	.625	.531	.438	.375	.313				
	8	.929	.821	.714	.607	.500	.429	.357					
	9	.885	.769	.654	.538	.462	.385						
	10	.870	.739	.609	.522	.435							
	11	.850	.700	.600	.500								
	12	.824	.706	.588									

TABLE A5.6

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred

0800-1559 EST	k											
	1	2	3	4	5	6	7	8	9	10	11	12
August i=0	.651	.505	.403	.317	.237	.172	.129	.097	.070	.048	.038	.027
1	.777	.620	.488	.364	.264	.198	.149	.107	.074	.058	.041	.025
2	.798	.628	.468	.340	.255	.191	.138	.096	.074	.053	.032	.011
3	.787	.587	.427	.320	.240	.173	.120	.093	.067	.040	.013	
4	.746	.542	.407	.305	.220	.153	.119	.085	.051	.017		
5	.727	.545	.409	.295	.205	.159	.114	.068	.023			
6	.750	.563	.406	.281	.219	.156	.094	.031				
7	.750	.542	.375	.292	.208	.125	.042					
8	.722	.500	.389	.278	.167	.056						
9	.692	.538	.385	.231	.077							
10	.778	.556	.333	.111								
11	.714	.429	.143									
12	.600	.200										
Summer i=0	.643	.484	.375	.297	.226	.174	.141	.116	.098	.080	.067	.056
1	.752	.583	.462	.352	.270	.220	.180	.152	.124	.104	.087	.070
2	.775	.614	.468	.360	.292	.240	.202	.165	.139	.116	.094	.075
3	.792	.604	.464	.377	.309	.261	.213	.179	.150	.121	.097	.077
4	.762	.585	.476	.390	.329	.268	.226	.189	.152	.122	.098	
5	.768	.624	.512	.432	.352	.296	.248	.200	.160	.128		
6	.813	.667	.563	.458	.385	.323	.260	.208	.167			
7	.821	.692	.564	.474	.397	.321	.256	.205				
8	.844	.688	.578	.484	.391	.313	.250					
9	.815	.685	.574	.463	.370	.296						
10	.841	.705	.568	.455	.364							
11	.838	.676	.541	.432								
12	.806	.645	.516									

TABLE A5.7

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred

1200-1959 EST		k											
		1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.594	.417	.322	.261	.211	.161	.133	.106	.083	.067	.050	.044
	1	.701	.542	.439	.355	.271	.224	.178	.140	.112	.084	.075	.065
	2	.773	.627	.507	.387	.320	.253	.200	.160	.120	.107	.093	.080
	3	.810	.655	.500	.414	.328	.259	.207	.155	.138	.121	.103	.086
	4	.809	.617	.511	.404	.319	.255	.191	.170	.149	.128	.106	
	5	.763	.632	.500	.395	.316	.237	.211	.184	.158	.132		
	6	.828	.655	.517	.414	.310	.276	.241	.207	.172			
	7	.792	.625	.500	.375	.333	.292	.250	.208				
	8	.789	.632	.474	.421	.368	.316	.263					
	9	.800	.600	.533	.467	.400	.333						
	10	.750	.667	.583	.500	.417							
	11	.889	.778	.667	.556								
	12	.875	.750	.625									
July	i=0	.559	.419	.312	.237	.183	.151	.129	.108	.097	.086	.075	.065
	1	.750	.558	.423	.327	.269	.231	.192	.173	.154	.135	.115	.096
	2	.744	.564	.436	.359	.308	.256	.231	.205	.179	.154	.128	.103
	3	.759	.586	.483	.414	.345	.310	.276	.241	.207	.172	.138	.103
	4	.773	.636	.545	.455	.409	.364	.318	.273	.227	.182	.136	
	5	.824	.706	.588	.529	.471	.412	.353	.294	.235	.176		
	6	.857	.714	.643	.571	.500	.429	.357	.286	.214			
	7	.833	.750	.667	.583	.500	.417	.333	.250				
	8	.900	.800	.700	.600	.500	.400	.300					
	9	.889	.778	.667	.556	.444	.333						
	10	.875	.750	.625	.500	.375							
	11	.857	.714	.571	.429								
	12	.833	.667	.500									

TABLE A5.8

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

1200-1959 EST		k											
		1	2	3	4	5	6	7	8	9	10	11	12
August	i=0	.586	.419	.317	.253	.188	.134	.097	.065	.043	.032	.022	.011
	1	.716	.541	.431	.321	.229	.165	.110	.073	.055	.037	.018	
	2	.756	.603	.449	.321	.231	.154	.103	.077	.051	.026		
	3	.797	.593	.424	.305	.203	.136	.102	.068	.034			
	4	.745	.532	.383	.255	.170	.128	.085	.043				
	5	.714	.514	.343	.229	.171	.114	.057					
	6	.720	.480	.320	.240	.160	.080						
	7	.667	.444	.333	.222	.111							
	8	.667	.500	.333	.167								
	9	.750	.500	.250									
	10	.667	.333										
	11	.500											
Summer	i=0	.580	.418	.317	.250	.194	.149	.120	.092	.074	.062	.049	.040
	1	.722	.547	.431	.334	.256	.206	.159	.128	.106	.084	.069	.053
	2	.758	.597	.463	.355	.286	.221	.177	.147	.117	.095	.074	.061
	3	.789	.611	.469	.377	.291	.234	.194	.154	.126	.097	.080	.063
	4	.775	.594	.478	.370	.297	.246	.196	.159	.123	.101	.080	
	5	.766	.617	.477	.383	.318	.252	.206	.159	.131	.103		
	6	.805	.622	.500	.415	.329	.268	.207	.171	.134			
	7	.773	.621	.515	.409	.333	.258	.212	.167				
	8	.804	.667	.529	.431	.333	.275	.216					
	9	.829	.659	.537	.415	.341	.268						
	10	.794	.647	.500	.412	.324							
	11	.815	.630	.519	.407								
	12	.773	.636	.500									

TABLE A5.9

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

1600-2359	EST	k											
		1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.717	.567	.467	.383	.311	.244	.194	.150	.111	.083	.067	.056
	1	.791	.651	.535	.434	.341	.271	.209	.155	.116	.093	.078	.062
	2	.824	.676	.549	.431	.343	.265	.196	.147	.118	.098	.078	.059
	3	.821	.667	.524	.417	.321	.238	.179	.143	.119	.095	.071	.048
	4	.812	.638	.507	.391	.290	.217	.174	.145	.116	.087	.058	
	5	.786	.625	.482	.357	.268	.214	.179	.143	.107	.071		
	6	.795	.614	.455	.341	.273	.227	.182	.136	.091			
	7	.771	.571	.429	.343	.286	.229	.171	.114				
	8	.741	.556	.444	.370	.296	.222	.148					
	9	.750	.600	.500	.400	.300	.200						
	10	.800	.667	.533	.400	.267							
	11	.833	.667	.500	.333								
	12	.800	.600	.400									
July	i=0	.624	.457	.355	.280	.231	.204	.172	.145	.129	.118	.108	.097
	1	.733	.569	.448	.371	.328	.276	.233	.207	.190	.172	.155	.138
	2	.776	.612	.506	.447	.376	.318	.282	.259	.235	.212	.188	.165
	3	.788	.652	.576	.485	.409	.364	.333	.303	.273	.242	.212	.182
	4	.827	.731	.615	.519	.462	.423	.385	.346	.308	.269	.231	
	5	.884	.744	.628	.558	.512	.465	.419	.372	.326	.279		
	6	.842	.711	.632	.579	.526	.474	.421	.368	.316			
	7	.844	.750	.688	.625	.563	.500	.438	.375				
	8	.889	.815	.741	.667	.593	.579	.444					
	9	.917	.833	.750	.667	.583	.500						
	10	.909	.818	.727	.636	.545							
	11	.900	.800	.700	.600								
	12	.889	.778	.667									

TABLE A5.10

ÈMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

1600-2359 EST		k 1	2	3	4	5	6	7	8	9	10	11	12
August	i=0	.720	.554	.419	.333	.258	.188	.140	.113	.097	.086	.075	.065
	1	.769	.582	.463	.358	.261	.194	.157	.134	.119	.104	.090	.082
	2	.757	.602	.466	.340	.252	.204	.175	.155	.136	.117	.107	.097
	3	.795	.615	.449	.333	.269	.231	.205	.179	.154	.141	.128	.103
	4	.774	.565	.419	.339	.290	.258	.226	.194	.177	.161	.129	
	5	.729	.542	.437	.375	.333	.292	.250	.229	.208	.167		
	6	.743	.600	.514	.457	.400	.343	.314	.286	.229			
	7	.808	.692	.615	.538	.462	.423	.385	.308				
	8	.857	.762	.667	.571	.524	.476	.381					
	9	.889	.778	.667	.611	.556	.444						
	10	.875	.750	.688	.625	.500							
	11	.857	.786	.714	.571								
	12	.917	.833	.667									
Summer	i=0	.687	.525	.413	.332	.266	.212	.168	.136	.112	.096	.083	.072
	1	.765	.602	.483	.388	.309	.245	.198	.164	.140	.121	.106	.092
	2	.786	.631	.507	.403	.321	.259	.214	.183	.159	.138	.121	.103
	3	.803	.645	.513	.408	.329	.272	.232	.202	.175	.154	.132	.105
	4	.803	.639	.508	.410	.339	.290	.251	.219	.191	.164	.131	
	5	.796	.633	.510	.422	.361	.313	.272	.238	.204	.163		
	6	.795	.641	.530	.453	.393	.342	.299	.256	.205			
	7	.806	.667	.570	.495	.430	.376	.323	.258				
	8	.827	.707	.613	.533	.467	.400	.320					
	9	.855	.742	.645	.565	.484	.387						
	10	.868	.755	.660	.566	.453							
	11	.870	.761	.652	.522								
	12	.875	.750	.600									

TABLE A5.11

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred

0000-2359 EST		k											
		1	2	3	4	5	6	7	8	9	10	11	12
June	i=0	.556	.394	.294	.233	.178	.133	.106	.083	.067	.056	.044	.039
	1	.710	.530	.420	.320	.240	.190	.150	.120	.100	.080	.070	.060
	2	.746	.592	.451	.338	.268	.211	.169	.141	.113	.099	.085	.070
	3	.792	.604	.453	.358	.283	.226	.189	.151	.132	.113	.094	.075
	4	.762	.571	.452	.357	.286	.238	.190	.167	.143	.119	.095	
	5	.750	.594	.469	.375	.313	.250	.219	.188	.156	.125		
	6	.792	.625	.500	.417	.333	.292	.250	.208	.167			
	7	.789	.632	.526	.421	.368	.316	.263	.211				
	8	.800	.667	.533	.467	[illegible]	.333	.267					
	9	.833	.667	.583	.500	.417	.333						
	10	.800	.700	.600	.500	.400							
	11	.875	.750	.625	.500								
	12	.857	.714	.571									
July	i=0	.548	.398	.285	.204	.151	.118	.097	.075	.065	.054	.043	.032
	1	.725	.520	.373	.275	.216	.176	.137	.118	.098	.078	.059	.039
	2	.716	.514	.378	.297	.243	.189	.162	.135	.108	.081	.054	.041
	3	.717	.528	.415	.340	.264	.226	.189	.151	.113	.075	.057	.038
	4	.737	.579	.474	.368	.316	.263	.211	.158	.105	.079	.053	
	5	.786	.643	.500	.429	.357	.286	.214	.143	.107	.071		
	6	.818	.636	.545	.455	.364	.273	.182	.136	.091			
	7	.778	.667	.556	.444	.333	.222	.167	.111				
	8	.857	.714	.571	.429	.286	.214	.143					
	9	.833	.667	.500	.333	.250	.167						
	10	.800	.600	.400	.300	.200							
	11	.750	.500	.375	.250								
	12	.667	.500	.333									

TABLE A5.12

EMPIRICAL CONDITIONAL PROBABILITIES

Probability of k additional consecutive days without thunderstorms during the indicated hours, given that i consecutive days without thunderstorms have just occurred.

0000-2359 EST		k=1	2	3	4	5	6	7	8	9	10	11	12
August	i=0	.500	.323	.210	.140	.086	.048	.032	.027	.022	.016	.011	.005
	1	.645	.419	.280	.172	.097	.065	.054	.043	.032	.022	.011	
	2	.650	.433	.267	.150	.100	.083	.067	.050	.033	.017		
	3	.667	.410	.231	.154	.128	.103	.077	.051	.026			
	4	.615	.346	.231	.192	.154	.115	.077	.038				
	5	.563	.375	.313	.250	.188	.125	.063					
	6	.667	.555	.444	.333	.222	.111						
	7	.833	.667	.500	.333	.167							
	8	.800	.600	.400	.200								
	9	.750	.500	.250									
	10	.667	.333										
	11	.500											
	12												
Summer	i=0	.534	.371	.263	.192	.138	.100	.078	.062	.051	.042	.033	.025
	1	.695	.492	.359	.258	.186	.146	.115	.095	.078	.061	.047	.034
	2	.707	.517	.371	.268	.210	.166	.137	.112	.088	.068	.049	.039
	3	.731	.524	.379	.297	.234	.193	.159	.124	.097	.069	.055	.041
	4	.717	.519	.406	.321	.264	.217	.170	.132	.094	.075	.057	
	5	.724	.566	.447	.368	.303	.237	.184	.132	.105	.079		
	6	.782	.618	.509	.418	.327	.255	.182	.145	.109			
	7	.791	.651	.535	.419	.326	.233	.186	.140				
	8	.824	.676	.529	.412	.294	.235	.176					
	9	.821	.643	.500	.357	.286	.214						
	10	.783	.609	.435	.348	.261							
	11	.778	.556	.444	.333								
	12	.714	.571	.429									

TABLE A6.1

Frequency Distribution of Maximum Wind Speeds

Observed with Thunderstorms at Cape Kennedy, Florida (1957-1962)

0000-2359 EST	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
0- 4 kt	0	0	0	0	0	0	0	2	0	0	0	1	3
5- 9 kt	0	2	3	2	9	14	6	19	11	9	0	2	77
10-14 kt	1	1	3	7	10	22	26	23	12	7	2	1	115
15-19 kt	0	1	2	0	8	12	14	15	8	3	1	0	64
20-24 kt	0	1	5	2	9	15	21	18	15	2	0	0	88
25-29 kt	1	3	4	4	4	8	9	9	9	0	1	0	52
30-34 kt	1	0	4	4	5	4	6	2	3	0	0	0	29
35-39 kt	0	1	1	1	1	3	2	3	2	1	0	0	15
40-44 kt	0	0	1	1	0	1	0	0	2	0	0	0	5
45-49 kt	0	0	0	0	0	1	0	0	0	0	0	0	1
Totals	3	9	23	21	46	80	84	91	62	22	4	4	449

TABLE A6.2

Frequency Distribution of Maximum Wind Speeds

Observed with Thunderstorms at Cape Kennedy, Florida (1957-1962)

1200- 1959 EST	June	July	Aug	Summer
0- 4 kt	0	0	0	0
5- 9 kt	10	5	9	24
10-14 kt	22	27	21	70
15-19 kt	11	13	14	38
20-24 kt	13	21	17	51
25-29 kt	8	8	9	25
30-34 kt	4	6	2	12
35-39 kt	3	2	3	8
40-44 kt	1	0	0	1
45-49 kt	1	0	0	1
Totals	73	82	75	230

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APPENDIX B

Testing Procedure for Order for Markov Chains

Adotevi-Akue et al [1] have shown that the appropriate forms of the asymptotically Chi-square statistic as derived by Billingsley [2] for testing the order of Markov chains (with two states and 4-day sequences) are:

For zero order,

$$\chi^2 = \sum_{a_1 \ldots a_4} \frac{\left(fa_1 \ldots a_4 - \frac{fa_1 \ldots a_3 \; fa_4}{N}\right)^2}{\frac{fa_1 \ldots a_3 \; fa_4}{N}}$$

with 7 degrees of freedom where the f's are the sequence frequencies and N is the total number of transitions.

For first order,

$$\chi^2 = \sum_{a_1 \ldots a_4} \frac{\left(fa_1 \ldots a_4 - \frac{fa_1 \ldots a_3 \; fa_3 a_4}{fa_3}\right)^2}{\frac{fa_1 \ldots a_3 fa_3 a_4}{fa_3}}$$

with 6 degrees of freedom.

For second order,

$$\chi^2 = \sum_{a_1 \ldots a_4} \frac{\left(fa_1 \ldots a_4 - \frac{fa_1 \ldots a_3 \; fa_2 \ldots a_4}{fa_2 \; a_3}\right)^2}{\frac{fa_1 \ldots a_3 \quad fa_2 \ldots a_4}{fa_2 \; a_3}}$$

with 4 degrees of freedom.

Degrees of freedom are determined by the relation

$$df = (S^{t+1} - S^t) - (S^{r+1} - S^r)$$

where S is the number of outcome, t is the number of days in the sequence minus one and r is the order of the model.

Sample Calculations of Chi-square

The following frequencies were extracted from 6 years, 1957-1962, of data at Cape Kennedy, Florida for the summer season. The time period is 1200 - 1959 EST. The 4-day sequences beginning on each day of the summer period were tabulated yielding a total of 552 frequencies for the 6-year period.

Sequence	Frequency	Sequence	Frequency
NNNN	138	TNNN	38
NNNT	37	TNNT	20
NNTN	23	TNTN	12
NNTT	33	TNTT	19
NTNN	22	TTNN	37
NTNT	16	TTNT	15
NTTN	20	TTTN	31
NTTT	32	TTTT	59

The letter "T" denotes thunderstorm occurrence and "N" non-occurrence.

If it is desired to test the above sequences for first order the appropriate statistic would be summed over the 16 sequences. For example, if we denote Δ as the centributum of each individual sequence to the total Chi-square, the Δ value for the first sequence (NNNN) would be:

$$\Delta = \frac{\left(138 - \frac{(175)(235)}{323}\right)^2}{\frac{(175)(235)}{323}} = 0.895526$$

where

$$f a_1 \ldots a_4 = 138; \; f a_1 \ldots a_3 = 175; \; f a_3 a_4 = 235; \; f a_3 = 323$$

The Chi-square value is,

$$\chi^2 = \sum_{i=1}^{16} \Delta i = 9.82338$$

The null hypothesis tested is that within the assumption that the process is Markovian, the order of dependence is one. Interpretation as to the significance of the above Chi-square value cannot be made until the results of the zero and second order tests can be evaluated.

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