Indications of a Lunar Synodical Period in United States Observations of Sunshine[1]

IVER A. LUND
Air Force Cambridge Research Laboratories, Bedford, Mass.
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ABSTRACT

An analysis of daily observations of sunshine taken in the central and northeastern United States during the spring and summer indicates the presence of a lunar synodical period. Less than average sunshine is observed during the first and third weeks of the lunar month and more than average sunshine is observed during the second and fourth weeks. Although this lunar period is significant by most statistical tests, the possibility that its appearance is due to a combination of the smoothing procedure and the temporal and spatial correlation among the observations cannot be completely ignored.

1. Introduction

Throughout the ages much has been written and believed about the "influences" of the moon upon the weather. Since these supposed influences have usually not survived unbiased statistical tests, most scientists have concluded that they are nonexistent. Baur (1951) stated, "No one has ever proved in a single case to date that during or after a given arrangement of the moon or the planets any weather phenomenon occurred more frequently or less frequently than would be expected by chance."

Despite the rather gloomy outlook for proving the existence of lunar-weather relationships, investigations have continued into this area of study. Now several authors claim to have definitely established the presence of significant influences of the moon on the atmosphere. Adderley and Bowen (1962) wrote, "The influence of the moon in producing tides in the upper atmosphere and the appearance of a lunar component in daily temperature in certain parts of the world are comparatively well known, but the effects are extremely small and difficult to detect." A paper by Brier and Bradley (1964) states, "A cycle of 14.765 days, one-half of the lunar synodic month, can be demonstrated in the preciptation data for the United States for the period 1871-1961." Other authors, Hartman (1962) and Bigg (1963), for example, also state that atmospheric variations are associated with the lunar phases.

Although such a relation had been suggested earlier by Mesnard (1920) and Rodès (1937), it was an article by Bradley, Woodbury and Brier (1962) on a relationship between precipitation activity and the phases of the moon that prompted the author to test some sunshine data (that was already on magnetic tape) for a similar relationship.[2] When substantial evidence for this relationship appeared, the investigation was extended to include more data. This paper presents all of the results of testing to determine whether a relationship exists between sunshine in the United States (by season) and the phases of the moon.

2. Lunar synodic period

The synodic period starts at New Moon and ends approximately 29.53 days later at the next New Moon. This period is called a lunation, or lunar month. For this study, the position of the moon during the lunar month, computed to the nearest hundredth of the lunar synodical period (synodical decimals), was taken from the ephemeris prepared by Carpenter (1962). The synodical decimals corresponding to the phases of the moon are 0.00 (New Moon), 0.25 (First Quarter), 0.50 (Full Moon), and 0.75 (Last Quarter). The decimals increase in value about 0.03 each day through the cycle from 0.00 to 0.99.

3. Sunshine models

According to Bradley, Woodbury and Brier (1962) heavy precipitation in the United States is more frequent between New Moon and First Quarter than between First Quarter and Full Moon. They also show that heavy precipitation is more frequent between Full Moon and Last Quarter than between Last Quarter and New Moon. Although it was recognized that cloudy periods may be precipitation free periods in some parts of the world, because of fog and stratus clouds, a negative correlation between sunshine and precipitation was thought to be

[1] Presented at the 45th Annual Meeting of the Pacific Division, American Association for the Advancement of Science, Vancouver, B. C., 22 June 1964.

[2] Lund, I. A., 1964: Indications of a lunar synodical period in sunshine observations for Boston, Massachusetts, and Columbia, Missouri: AFCRL-64-150, Environmental Research Paper No. 9 Air Force Cambridge Research Laboratories, L. G. Hanscom Fld, Bedford, Mass., 11 pp.

more generally observed. Based on the precipitation results two simple and similar sunshine models were tested. In Model A, it is assumed that the sunshine departures from the average percentage of possible sunshine, are negative, positive, negative, positive as shown in Fig. 1. In Model B, it is assumed that the sunshine departures, follow the two-period sine curve also shown in Fig. 1.

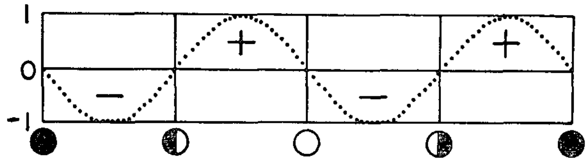

FIG. 1. The two sunshine models. Model A is represented by the negative and positive signs, Model B by the sinusoidal curve.

4. Sunshine observations

Instruments that automatically record the length of time the sun shines each day have been in use at numerous observing stations throughout the world. Many stations have continuous sunshine records for more than 50 years. Although these records are subject to considerable error, there is no reason to believe they are biased according to the position of the moon. Since the length of the day varies with the time of year, the number of minutes the sun shone each day is divided by the number of minutes from sunrise to sunset, to remove variations due solely to the time of the year. The resulting parameter is termed "per cent of possible sunshine."

5. Stations

The daily observations of per cent of possible sunshine used in this study were taken at ten stations in the United States during the interval of time from 1 January 1905 through 31 December 1962. The stations are shown in Fig. 2 (Honolulu excepted) and listed below:

1. Bismarck, North Dakota (BIS)
2. Boston, Massachusetts (BOS)
3. Columbia, Missouri (CBI)
4. Columbus, Ohio (CMH)
5. Grand Junction, Colorado (GJT)
6. Honolulu, Hawaii (HON)
7. Oklahoma City, Oklahoma (OKC)
8. San Diego, California (SAN)
9. Seattle, Washington (SEA)
10. Tampa, Florida (TPA)

6. Analysis

During the 58-year period from 1905 through 1962 there were 717.37 lunar synodical periods of 29.53 days each. The synodical decimals described in Section 2 giving the moon's position at Greenwich noon (1200 UT) on each day were written on magnetic tape. The 211,840 sunshine observations taken at the ten stations on the 21,184 days during the 58-year period were also written on tape. Less than one-tenth of one per cent of the observations were missing. When an observation was missing the station's annual average percentage of possible sunshine, taken from United States Weather Bureau records (1951), was inserted. A computer program was prepared to perform a superposed epoch analysis on these data in the following manner. The average amount of sunshine at New Moon (synodical decimal equal to 0.00) and on each hundredth of a period thereafter was computed. Moving averages were found for each tenth of the lunar synodical period. The averaging corresponds to approximately three-day smoothing. Before finding the average sunshine for each of the hundred synodical decimals, the years were divided into four seasons, namely; winter (December, January, February), spring (March, April, May), summer (June, July, August) and fall (September, October, November). There were approximately 5300 observations included in each season at each station.

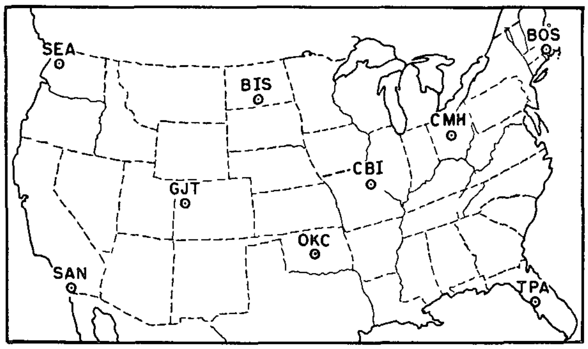

FIG. 2. Geographical location of the stations.

7. Results

After the computations were performed, the moving averages were plotted as a function of the synodical decimals. They are shown in Figs. 3 through 8. The letters on the graphs identify the stations (or seasons). On the ordinate is given the per cent of possible sunshine (or departures from the mean) and the synodic decimals are given along the abscissa (0.00, 0.25, 0.50 and 0.75 are represented by the moon's phases). The horizontal line on each graph marks the average sunshine. Departures from the average are darkened to make them stand out better.

7.1 Spring. The graphs for spring (March, April, May) are shown in Fig. 3. Each graph is based on more than 5000 observations. In the upper left hand corner are the call letters BIS which stand for Bismarck, North Dakota. The horizontal line at 57.9 shows that in the springtime Bismarck is sunny approximately 58 per cent of the time between sunrise and sunset. The darkened area between New Moon and First Quarter is not predominantly below the average as our models indicate, neither are they above average from First Quarter to Full Moon. After Full Moon the departures fit the sunshine models well.

The graph of the Boston data fits our models somewhat better than the Bismarck graph. Only for the period from Full Moon to Last Quarter are the departures predominantly of the wrong sign.

At Columbia, Missouri, there is strong evidence of the 14.765 day period found in precipitation data by Bradley, Woodbury and Brier.

The graphs for Columbus, Ohio; Grand Junction, Colorado; Oklahoma City, Oklahoma; and San Diego, California, also show clear indications of a lunar synodical period consistent with the sunshine models.

Even Seattle, Washington, and Tampa, Florida, show some signs of fitting the models. Honolulu is out of phase for three out of the four divisions in Model A.

7.2 Summer. Fig. 4 depicts the sunshine departures from the mean during the summer (June, July, August). Bismarck now fits the models much better than it did in the spring. Boston fits fairly well except after Last Quarter. Columbia fits exceptionally well and the departures are large. The per cent of sunshine ranges from less than 67 about three days after New Moon to more than 74 a few days before Full Moon. This is more than a seven per cent spread. It is the same amount of spread as from the cloudiest area in Ohio (Toledo near Lake Erie) to the clearest area in Ohio (Cincinnati in the southwest corner of the state)—a rather pronounced difference in sunshine.

Columbus also fits the models very well. Oklahoma City fits the models except for the period from Full Moon to Last Quarter. The departures at the other stations do not seem to agree with the models.

In general the graphs for summer did not fit the models as well as they did in the spring although Columbia, Columbus and Bismarck fit very well.

7.3 Fall. The sunshine departures from the mean in the fall (September, October, November) are shown in Fig. 5. In general, the graphs do not appear to fit the models. There is evidence of a phase shift, especially at Columbia, Columbus, and Grand Junction, with above average sunshine until a few days before Full Moon and below average sunshine thereafter. There is considerable evidence of a 180 degree shift in phase at San Diego.

7.4 Winter. Much like in the fall, evidence of a 14.765 day period is rather hard to find in the graphs for winter (December, January, February) shown in Fig. 6. Boston, Columbia, Columbus, Grand Junction and Honolulu show generally above average sunshine before Full Moon and below average sunshine after Full Moon but our initial tests did not include finding the significance of this arrangement of the departures.

7.5 All stations combined. Fig. 7 shows the results of lumping all of our data together, first by seasons, and then the entire 211,840 observations. There are more then 50,000 observations included in each data sample used to prepare the seasonal graphs. None of the observations have been excluded. The ordinate on these graphs is not the total departure but rather the average departure.

It can be clearly seen that the graph for spring (SP) fits our models very well. The graph for summer (SU) also agrees quite well with our models. In the fall (FA) there is just one distinct positive area and one distinct negative area. These areas are out of phase by about four days with the spring and summer departures preceding and following Full Moon. In the winter (WI) there are mostly positive values before Full Moon and negative values after Full Moon. As in the fall the departures do not fit the models. The arrangement of the departures is such that when all of the data are considered together the annual (AN) values again agree with the models quite well.

To determine whether large departures at only one or two stations were responsible for shape of the graphs when data from all ten stations were combined, graphs were prepared of the number of stations showing positive departures at each of the one hundred positions of the moon. Only the sign of the departure was considered. The magnitude is ignored. The graph for spring in the upper right-hand corner of Fig. 7 shows that only two or three of the stations were above average before First Quarter, as many as eight after First Quarter, as few as none after Full Moon and usually eight or nine after Last Quarter. In the summer the pattern is similar but not so pronounced. The fall, winter and annual graphs showing the sign of the departures match the corresponding graphs on the left side of the figure quite well. It is clear that the shape of the curves on the left side of Fig. 7 can not be attributed to observations from only one or two stations.

7.6 Five stations combined. Since a lunar period resembling the one obtained by Bradley, Woodbury and Brier (1962) appeared to be most pronounced in the data taken at stations in central and northeastern United States during the spring and summer, data from this area were combined for special study. The combined departures from the average sunshine observed at Bismarck, Boston, Columbia, Columbus and Oklahoma City during the spring and summer are shown in Fig. 8.

8. Sunspot number

During the period from 1905 through 1962 there were 29 years when the mean annual sunspot number exceeded 48.0 and an equal number of years when it did not, according to the values published by Chernosky and Hagan (1958).[3] This median value was used to

[3] Values computed after 1957 were provided to the author by Mr. Chernosky.

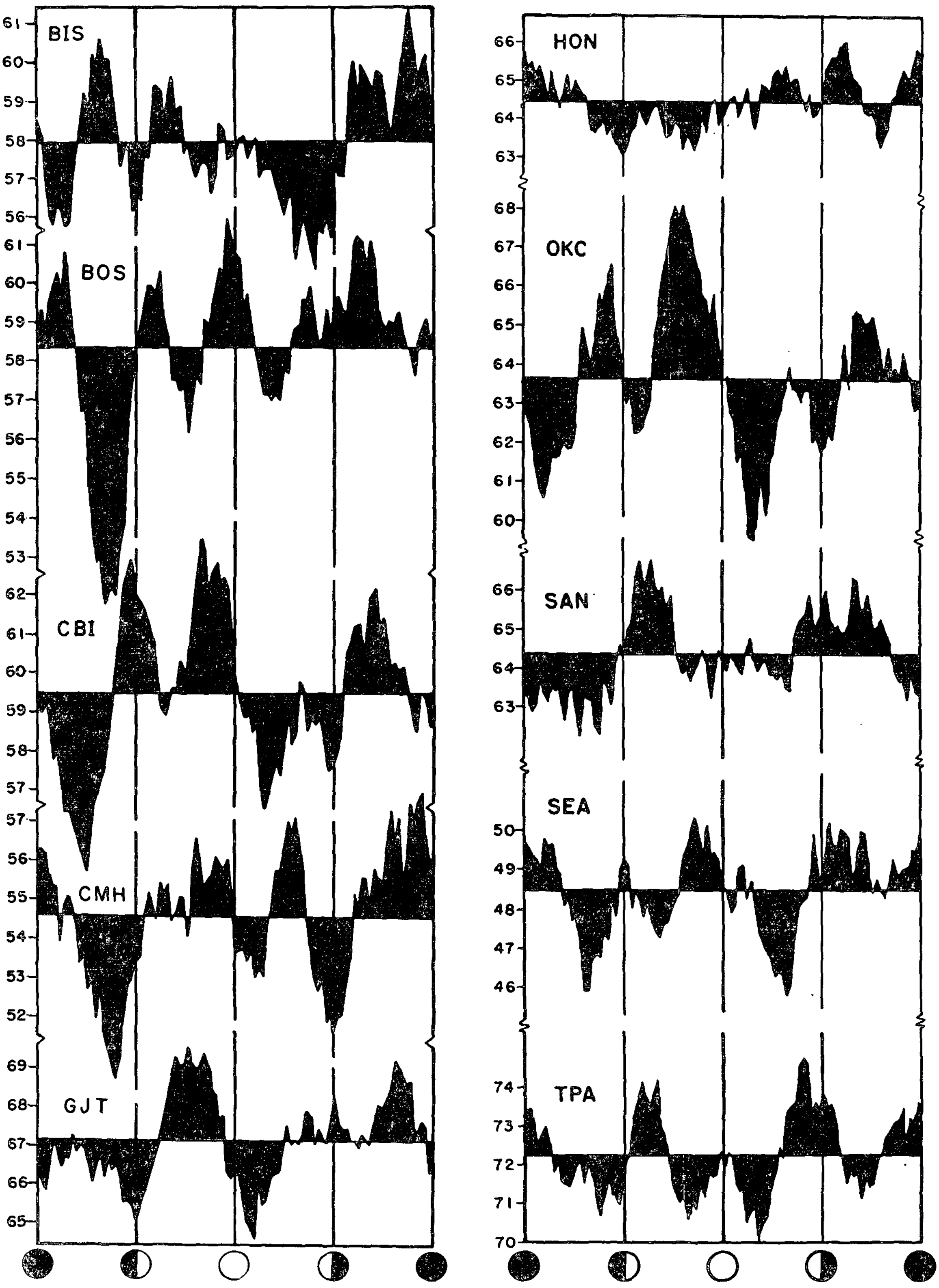

FIG. 3. Per cent of possible sunshine as a function of the phase of the moon in the spring (1905–1962).

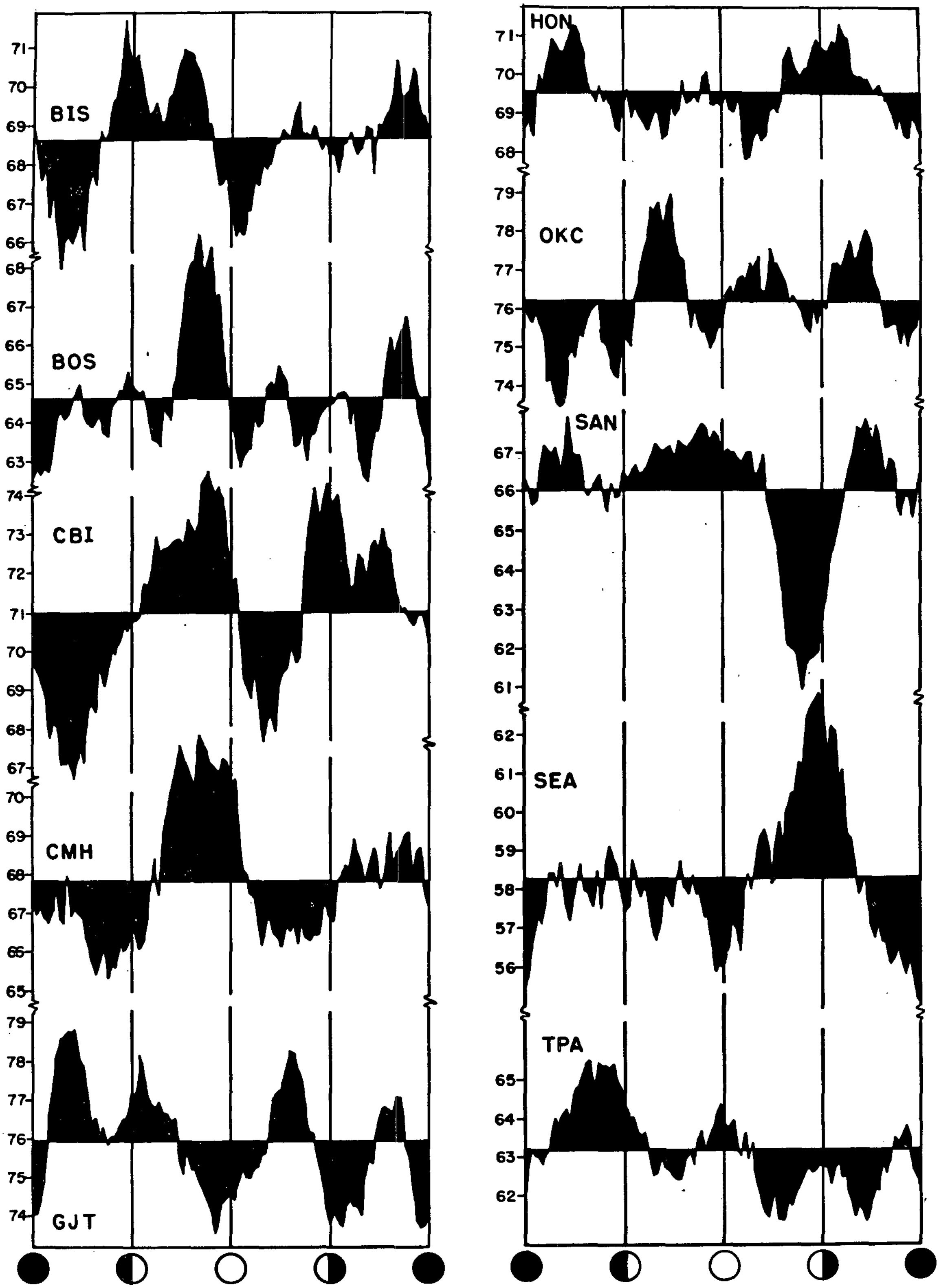

FIG. 4. Per cent of possible sunshine as a function of the phase of the moon in the summer (1905–1962).

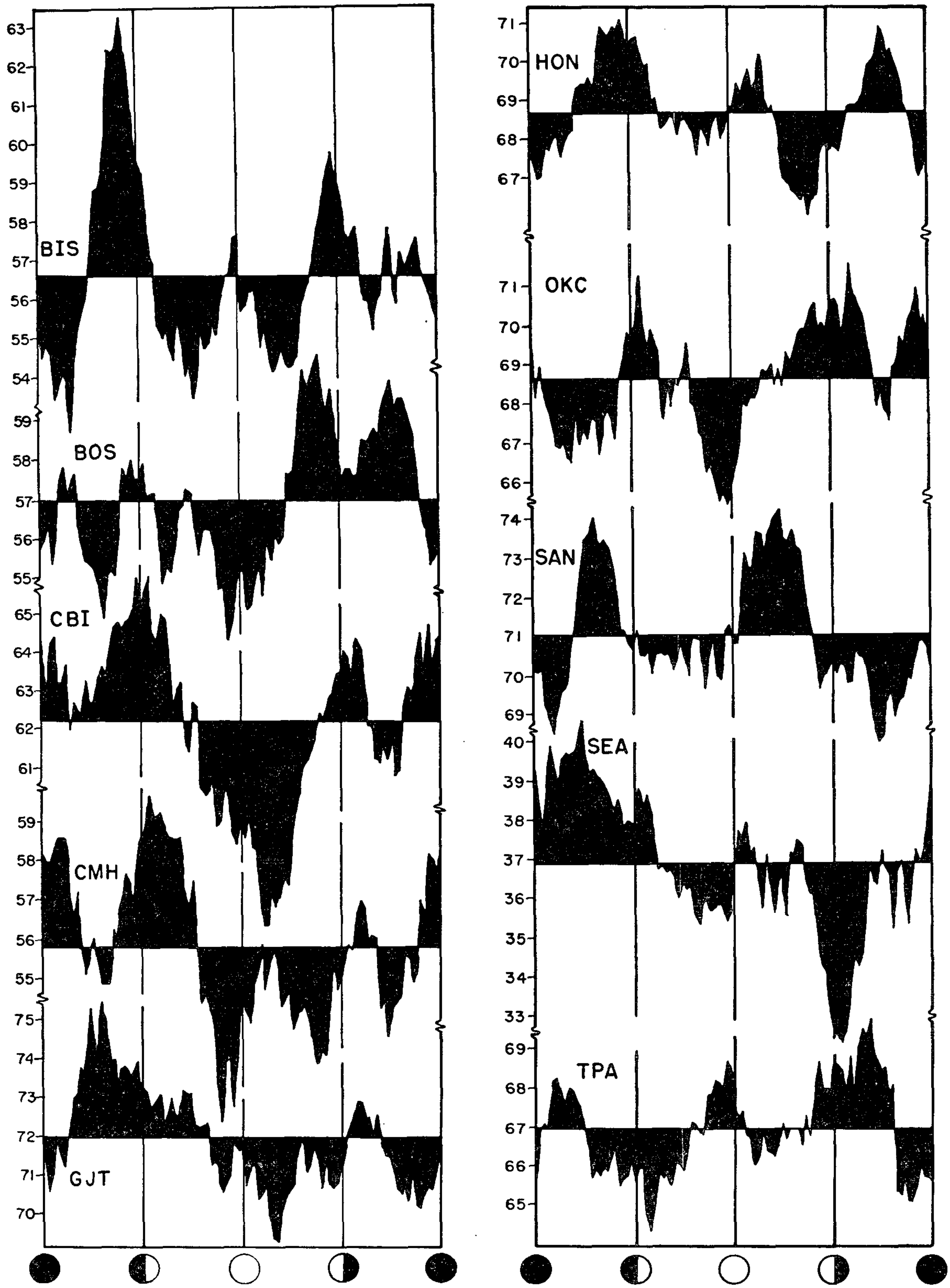

FIG. 5. Per cent of possible sunshine as a function of the phase of the moon in the fall (1905–1962).

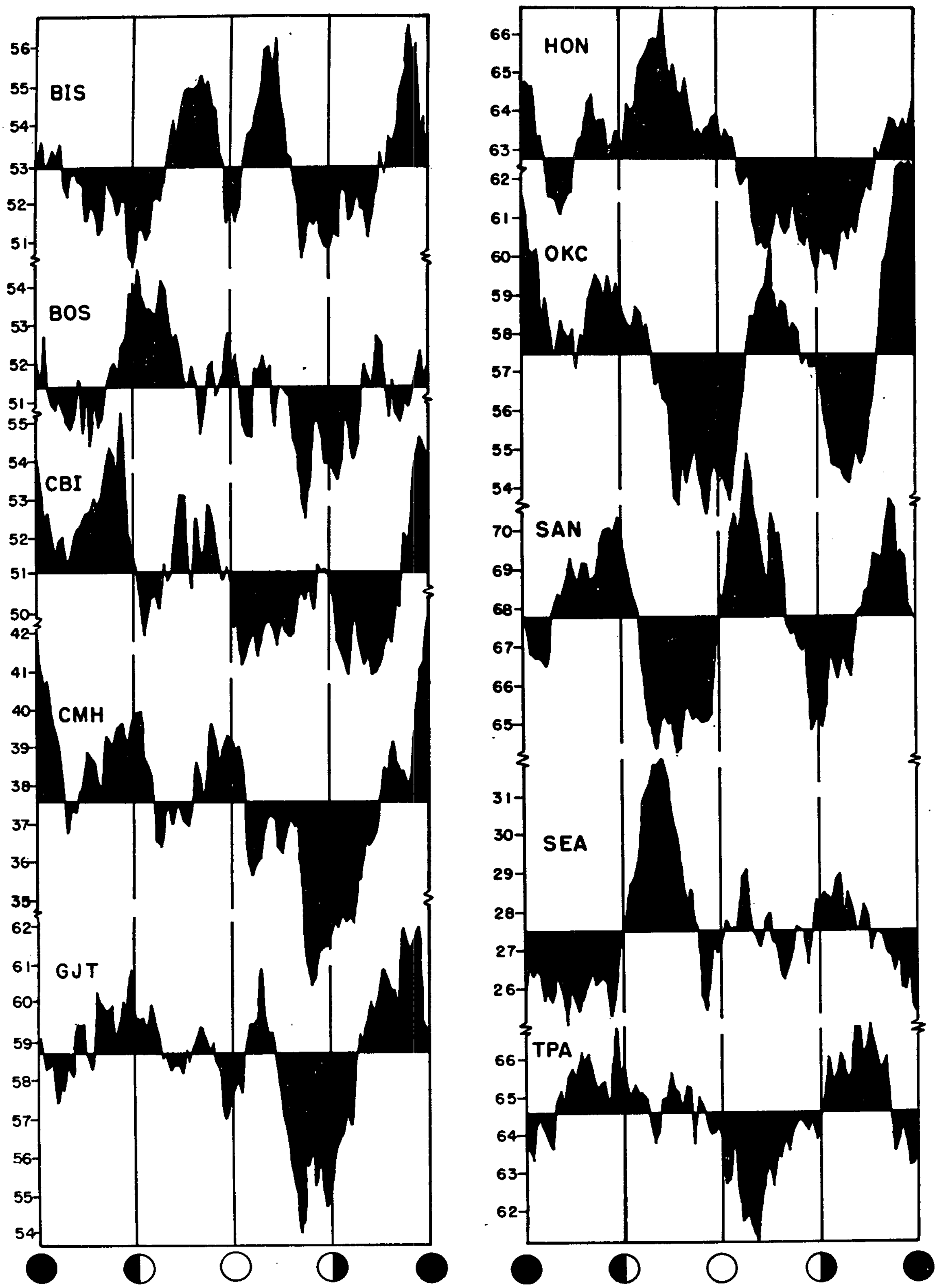

FIG. 6. Per cent of possible sunshine as a function of the phase of the moon in the winter (1905–1962).

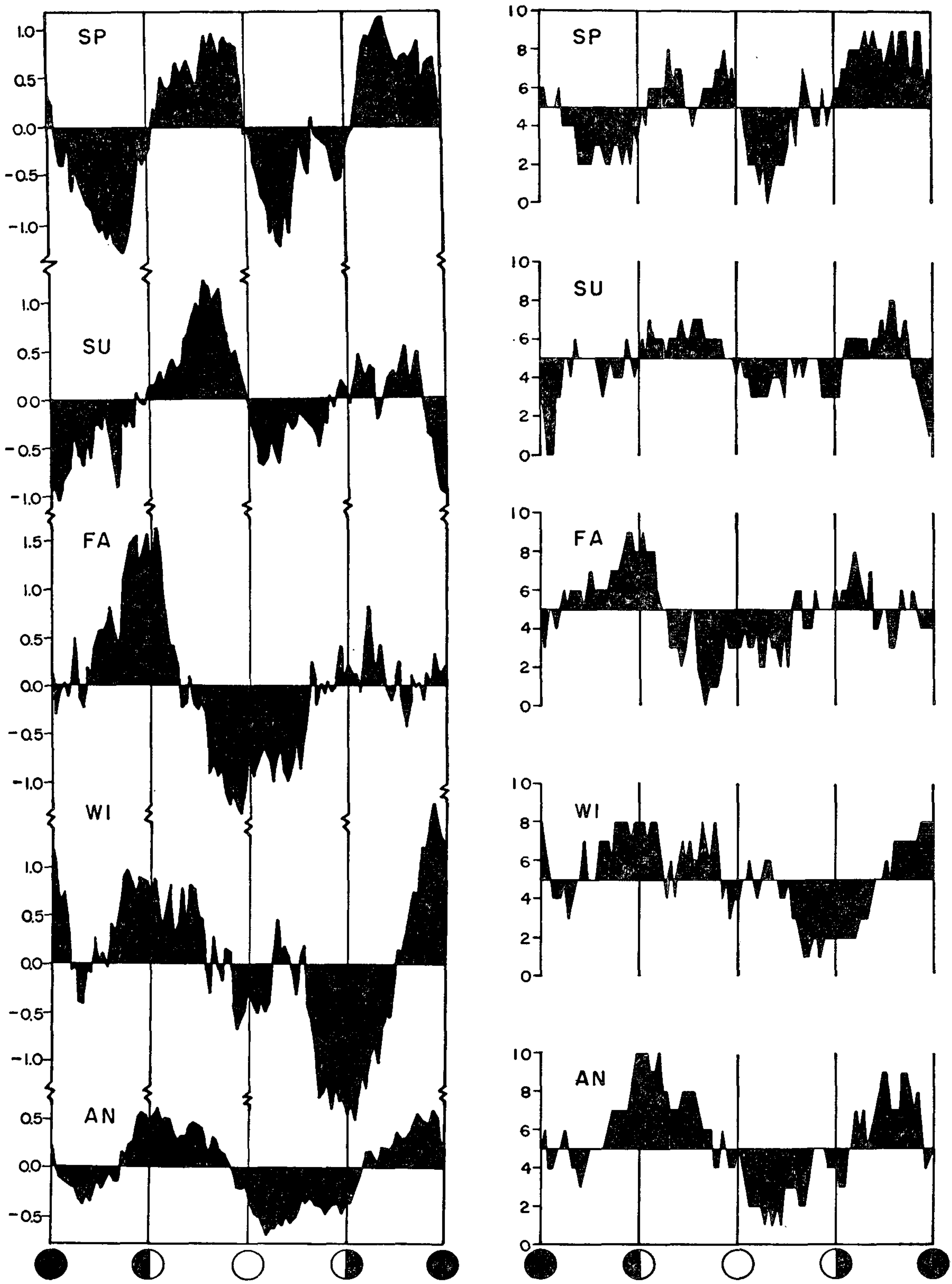

FIG. 7. Average departures (Column 1) when the data from all stations are combined and number of stations (Column 2) with above average sunshine, as a function of the phase of the moon.

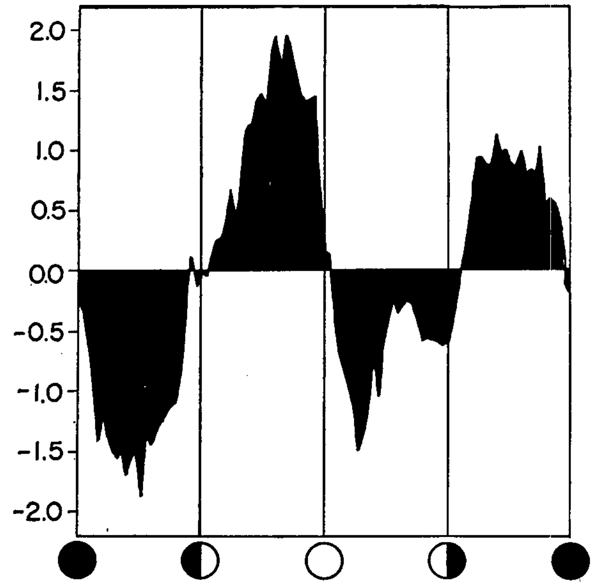

FIG. 8. Average departures, in per cent, when data observed at the five stations, BIS, BOS, CBI, CMH, OKC during the two seasons, spring, summer are combined, as a function of the phase of the moon.

prepare a "High" sunspot number and a "Low" sunspot number sample of data. Data from the years 1905, 06, 07, 08, 16, 17, 18, 19, 26, 27, 28, 29, 36, 37, 38, 39, 40, 46, 47, 48, 49, 50, 51, 56, 57, 58, 59, 60 and 1961 were included in the "High" sample and data from the remaining years were included in the "Low" sample.

The average observed sunshine at BIS, BOS, CBI, CMH, OKC, during the spring and summer as a function of the phase of the moon, during periods of "High" and "Low" sunspot numbers is shown in Fig. 9. The 14.765 day period is present in both samples of data. The departures before Full Moon are greater during low solar activity than during high solar activity. The graphs are also somewhat different after full moon but the significance of these differences is not known.

TABLE 1. Sunshine departures according to Model A.

Station	Synodic decimal 0.00–0.24	0.25–0.49	0.50–0.74	0.75–0.99
BIS	+ 1	− 0.1	−35	+34
BOS	−48	+15	+ 8	+23
CBI	−31	+43	−29	+16
CMH	−28	+13	− 7	+21
GJT	−18	+17	−15	+16
HON	+ 2	−14	+ 4	+ 9
OKC	−10	+42	−38	+ 6
SAN	−21	+14	− 2	+12
SEA	− 4	+ 5	−13	+17
TPA	− 6	+ 2	− 4	+ 4

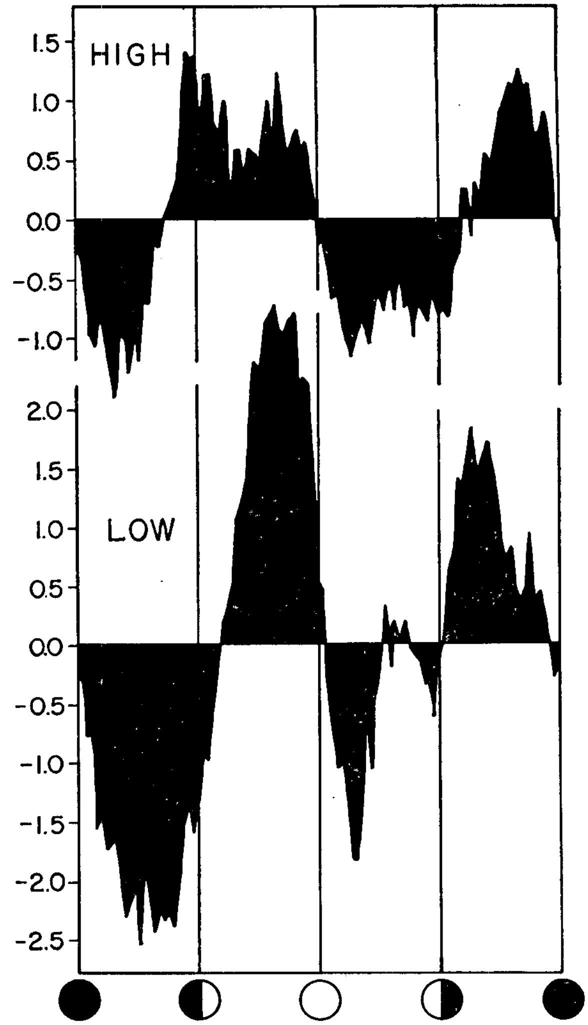

FIG. 9. Average departures, in per cent, as a function of the phase of the moon, during periods of "high" and "low" sunspot numbers.

9. Significance tests

Several tests have been performed to determine the statistical significance of the results obtained from this study. They are described below.

9.1 Model A. The sunshine departures, according to Model A, should be alternately below and above average from one phase of the moon to the next. The actual departures observed in the spring are given in Table 1.

When negative signs from New Moon to First Quarter (0.00–0.24) were expected, eight negative values and two small positive values were observed. After First Quarter (0.25–0.49) eight of the ten values are positive and the two negative values are small. After Full Moon (0.50–0.74) eight negative values were again observed, and after Last Quarter (0.75–0.99) all of the values were positive. The number of matches between the model and the observations is shown below:

Observed (spring)

		+	−	
Model	+	18	2	20
	−	4	16	20
		22	18	40

If it is assumed that all of the observations are independent of one another, which is probably a poor assumption, the probability of 34 out of 40 departures fitting the model, by chance, would be less than one in 10,000.

In summer the distribution of the positive and negative signs was not so impressive and the probability of finding the observed distribution, by chance, is about one in 100.

In the fall the distribution was almost perfectly random as shown below:

Observed (fall)

		+	−	
Model	+	10	10	20
	−	11	9	20
		21	19	40

The winter departures were also insignificant but the annual values were significant, with only three chances in 1000 of being unrelated to the model.

From this test the spring, summer, and annual values appear to be related to the position of the moon.

9.2 Model B. Our computer program included a computation of the correlation coefficient between the observed departures and the two-period sine curve used as our other model. The correlation coefficients computed for the spring were as follows: BIS 0.43, BOS 0.38, CBI 0.69, CMH 0.40, GJT 0.63, HON −0.26,

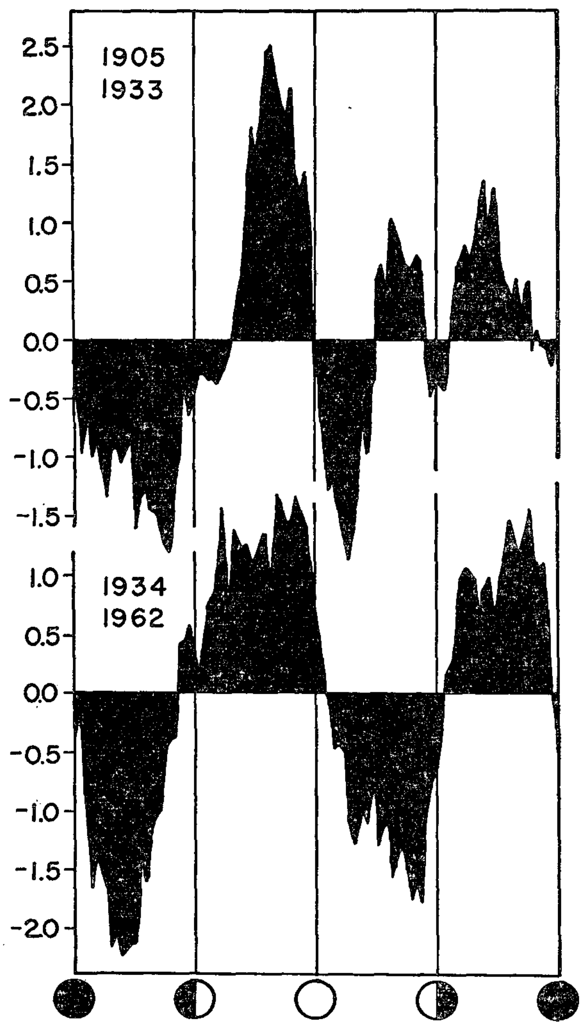

FIG. 10. Spring and summer departures at five stations (BIS, BOS, CBI, CMH, OKC) during two periods of 29 years each.

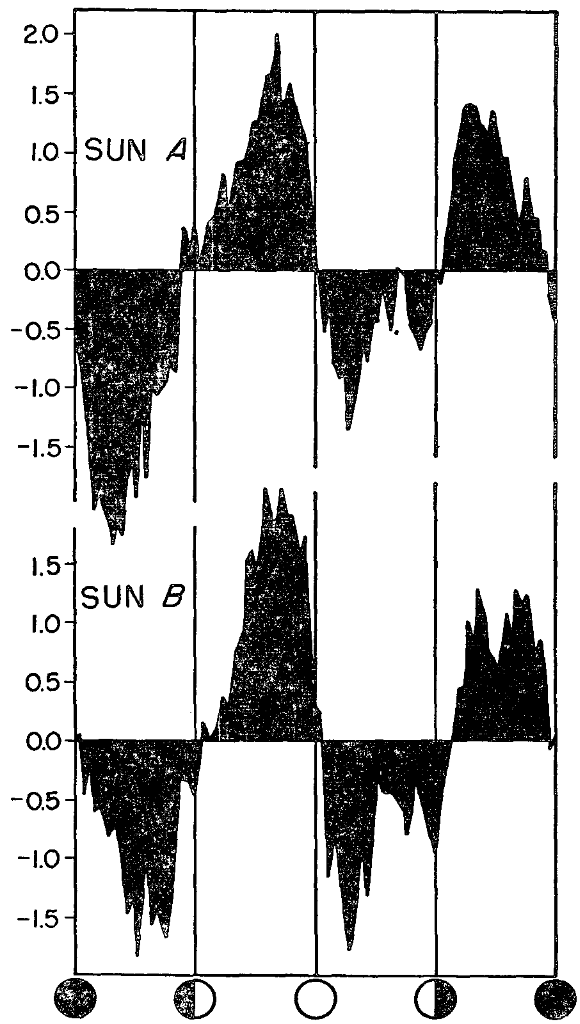

FIG. 11. Spring and summer departures at five stations (BIS, BOS, CBI, CMH, OKC) during two 29-year periods of similar solar activity.

OKC 0.60, SAN 0.58, SEA 0.49 and TPA 0.11. Nine of the ten coefficients were positive which is significant at the one per cent level.

The highest correlations were found in the summer (0.71 at CBI and 0.70 at CMH, see Fig. 4) but only six stations were positively correlated in summer. The number of positive coefficients in the fall and winter were six and seven, respectively. These could have easily occurred by chance.

The values for the annual averages (graphs of the annual averages, by station, are not shown) were positively correlated with the model at nine of the ten stations. The largest correlation coefficients between the model and the observed annual sunshine values were found at Boston (0.60) and Columbia (0.61).

Each correlation coefficient was based on 100 pairs of values, but, as explained earlier, the sunshine values include a ten-unit smoothing which introduces a very high correlation from one value to the next. If 18 independent pairs of values are assumed, there is about one chance in 200 of finding a correlation coefficient greater than 0.59 if no real correlation exists. Seven values greater than this figure were found: three in the spring, two in the summer, and two in the annual averages.

Tests of Model B also indicate a lunar-sunshine relationship in the spring, summer and annual periods. This, of course, is not an independent test since the two models are much alike.

9.3 Two samples (1905–1933; 1934–1962). Spring and summer data for the five stations BIS, BOS, CBI, CMH and OKC were divided into two parts to find out whether the apparent lunar-sunshine relationship shown in Fig. 8 was consistent from one sample of data to another. Sample 1 consisted of observations taken during the first 29 years under study and sample 2 consisted of observations taken during the remaining 29 years. The graphs of the departures from the average sunshine are shown in Fig. 10.

The graph based on observations taken during the period from 1934 through 1962 fits the models extremely well. The graph for 1905 through 1933 also matches Model A perfectly, but it is a poorer fit to Model B because of the positive departures between Full Moon and Last Quarter. The correlation coefficient of 0.596 between the two graphs is highly significant (at the 1 per cent level) if the 100 pairs of values used are assumed to be equivalent to more than 16 independent pairs.

9.4 Two samples (matched according to sunspot numbers). In Section 8 of this paper, it was noted that the suspected lunar-sunshine relationship might be a function of solar activity. If so, a comparison between two samples of data with similar amounts of solar activity would be a better test of consistency between samples than the two sample test described in Section 9.3. To balance the effect of solar activity within each of two samples, the annual mean relative sunspot numbers observed during the 58 year period were ranked from the highest number to the lowest number. Data for the years ranked 2, 4, 6, . . ., 58 were included in the sample designated "Sun A" and data for the years ranked 1, 3, 5, . . ., 57 were included in sample "Sun B." Observations taken during 1905, 06, 10, 11, 13, 15, 16, 21, 25, 26, 30, 34, 36, 37, 38, 40, 43, 44, 46, 47, 48, 50, 51, 52, 53, 54, 55, 58 and 1962 were included in "Sun A" and observations taken during the remaining years were included in "Sun B." The graphs of the departures from the average sunshine at the five stations (BIS, BOS, CBI, CMH, OKC) during the spring and summer are shown in Fig. 11.

It can be seen from the graphs that both of these samples also exhibit a well defined 14.765 day period. The correlation between the two curves is 0.853. This is significantly higher (at the 5 per cent level) than the value of 0.596 obtained between curves for the two 29 year periods described in subsection 9.3, if more than 14 independent pairs of values is assumed.

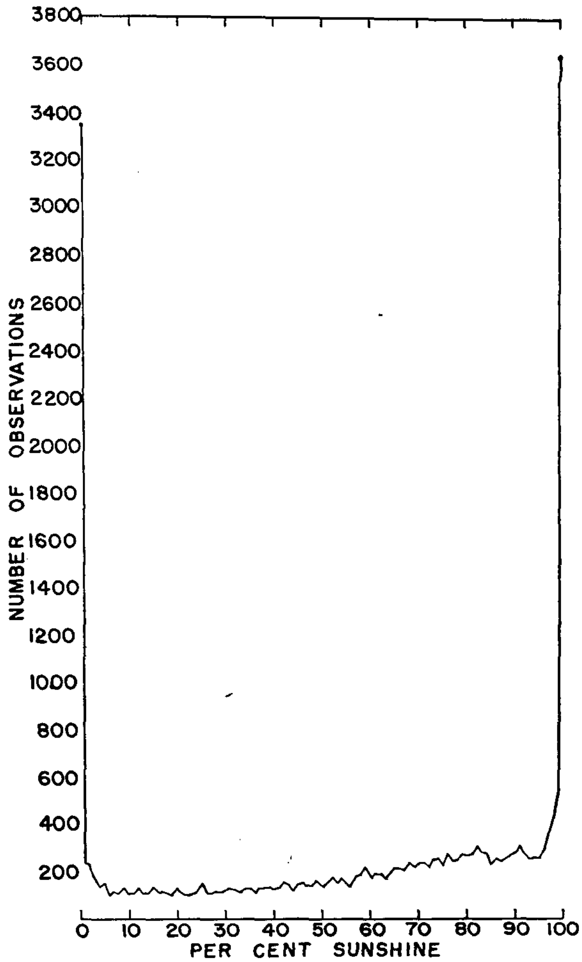

FIG. 12. The distribution of per cent of possible sunshine at Boston, Mass. (1894–1962).

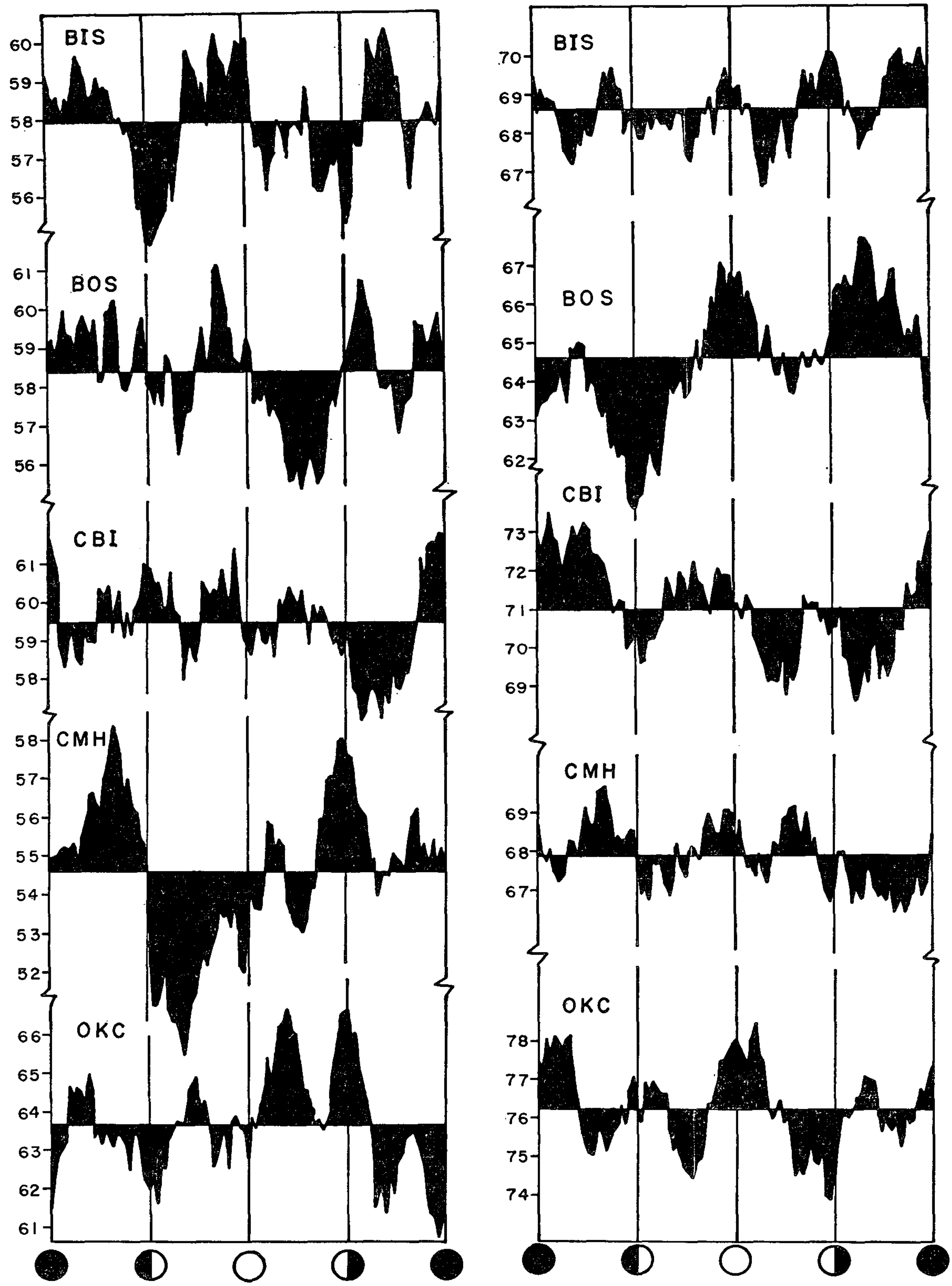

FIG. 13. Spring (Column 1) and summer (Column 2) departures when random numbers were used instead of the synodical decimals.

9.5 Monte Carlo tests. The per cent of possible sunshine observations are often distributed in an almost perfect U-shaped distribution. For an example, see Fig. 12 for the distribution of the sunshine observations taken at Boston during the period from 1894 through 1962. Furthermore, daily observations of sunshine cannot be regarded as random variables owing to serial correlation in the data. Although the serial correlation is rather small (at Boston, for example, it was only 0.216 from one observation to the next, 24-hour separation, and 0.038 for the observations separated by 48 hours) it still reduces the variance between observations closely spaced in time. Non-normal distributions of serially correlated observations do not lend themselves to standard statistical tests.

9.5.1 Random test 1. An experiment was designed to disassociate the observations from the phase of the moon, maintain the same frequency distribution of the observations and keep the same smoothing procedure. This was accomplished by replacing the tape of the true sequence of synodical decimals with tapes of random numbers which were generated so that every number from 0.00 through 0.99 was equally likely to occur. The exactly identical computer program, used for the previous calculations, was run on the spring and summer data for the five stations referred to in Section 7.6. Graphs of the results are shown in Figs. 13 and 14. These graphs are based on identically the same data as the corresponding graphs in Figs. 3, 4 and 8, only the arrangement of the data differs.

Almost all of the graphs shown in Fig. 13 are a poorer fit of our models than the corresponding graphs in Figs. 3 and 4. There is, however, evidence that even a random arrangement of the data can yield what might appear to be a lunar synodical period. This is best shown by the portion of the Columbus (CMH) spring curve between New Moon and Full Moon.

The lunar synodical period shown in Fig. 8 is not present in Fig. 14 but the largest departures shown in Fig. 14 are almost as large as the largest departures shown in Fig. 8.

9.5.2 Random test 2. An attempt was made to maintain most of the serial correlation in the time series of sunshine observations even in the random scrambling of the data. The computer was instructed to select the first 3 synodical decimals from a tape comprised of synodical decimals for every day from 1 Jan. 1894 through 31 Dec. 1962, skip a random number of days (the random numbers consisted of values selected at random from a rectangular distribution of numbers varying from 00 through 99), select the next 3 synodical decimals, skip a random number of synodical decimals, select the next 3 synodical decimals, etc., until five tapes of 21,184 scrambled synodical decimals, in sets of 3 at a time, were selected from the original tape of 25,201 decimals. This selection required cycling through the original tape of synodical decimals many times since an average of 50 decimals were skipped over between each selection of 3 consecutive values.

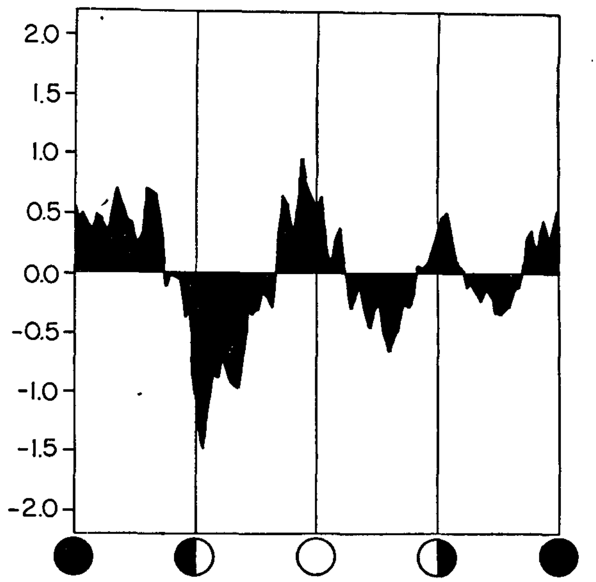

FIG. 14. Spring and summer departures when random numbers were used instead of the synodical decimals and the departures were combined for the five stations (BIS, BOS, CBI, CMH, OKC).

The new tapes of 21,184 synodical decimals were again used to replace the tape of the true sequence of decimals and the exactly identical computer program was run once more on the spring and summer data for the five stations referred to in Section 7.6. Graphs of the results are shown in Figs. 15 and 16. A comparison of the graphs shown in Fig. 15 with the corresponding graphs in Figs. 3 and 4 again show that the curves based on data arranged according to the true synodical decimals generally fit our models better than curves based on data arranged randomly in sets of 3. There are, however, some exceptions. The most striking exception is Oklahoma City (OKC) in the spring. Here we see the random curve fitting our models better than any curve shown in this entire paper. The correlation between this curve and Model B is 0.82. This demonstrates that a spurious lunar component may appear even in a relatively small number of trials.

The period shown in Fig. 8 is also present in Fig. 16, however, its amplitude is not as great.

The combined effect of the smoothing procedure and the autocorrelation in the time series could conceiveably be responsible for the appearance of a lunar period. This test at least suggests this possibility.

9.5.3 Random versus actual. With five stations, two seasons and four lunar weeks, there were a total of 40 times when the sum of the departures could be tested with departures defined by Model A. The results are given in the tables shown below:

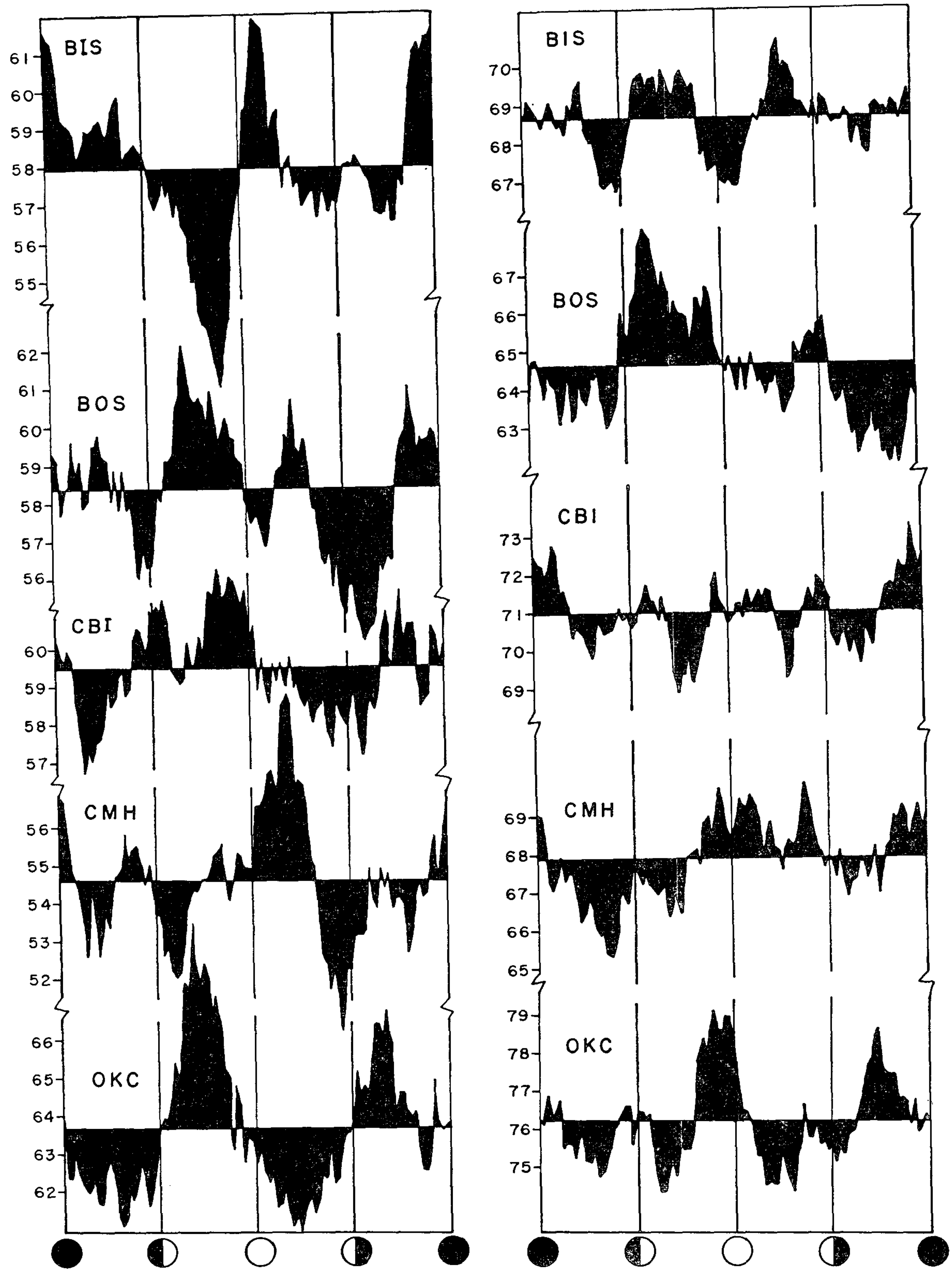

FIG. 15. Spring (Column 1) and summer (Column 2) departures after the data were randomly scrambled in sets of 3 consecutive values.

Actual

		+	−	
Model	+	19	1	20
	−	4	16	20
		23	17	40

Random 1

		+	−	
Model	+	9	11	20
	−	11	9	20
		20	20	40

Random 2

		+	−	
Model	+	12	8	20
	−	7	13	20
		19	21	40

It can be seen that 35, 18 and 25 departures matched the models in the actual, Random 1, and Random 2, respectively.

The correlation coefficients with Model B are shown in Table 2.

TABLE 2. Correlation coefficients with Model B for actual and random departures.

Station	Season	Actual	Random 1	Random 2
BIS	SP	0.43	0.15	−0.48
BOS	SP	0.38	0.25	0.11
CBI	SP	0.69	−0.18	0.50
CMH	SP	0.40	−0.47	−0.26
OKC	SP	0.60	−0.38	0.82
BIS	SU	0.54	0.19	0.14
BOS	SU	0.37	0.26	0.19
CBI	SU	0.71	−0.15	−0.14
CMH	SU	0.70	−0.52	0.07
OKC	SU	0.41	−0.05	0.48

The "Actual" (when the correct synodical decimals were used) correlations are all greater than the corresponding ones in Random 1. Two of the Random 2 correlations are larger than the corresponding correlations in the Actual Column.

The reader should bear in mind that the above mentioned five stations and two seasons were selected from a sample of ten stations and four seasons. This selection has served to improve the "Actual" results.

10. Comments

The statistical evidence favoring a 14.765 day period in sunshine observations, taken during spring and summer in central and northeastern United States during the past 58 years, is sufficiently convincing to justify performing further analysis of sunshine data. In addition to examining the data observed in the United States more closely, expecially the fall and winter observations, the processing of sunshine data observed at three stations in Japan and two stations in Europe is now underway.

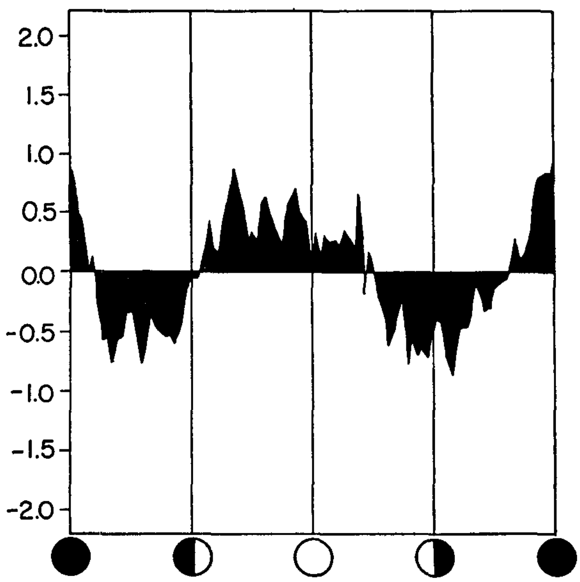

FIG. 16. Spring and summer departures after the data were randomly scrambled in sets of 3 consecutive values and then combined for the five stations (BIS, BOS, CBI, CMH, OKC).

A search for a physical explanation of the highly probable relationship between the position of the moon and sunshine (cloudiness) seems reasonable. The results shown in Section 8 and subsection 9.4 indicate that solar activity should be investigated further. Atmospheric tides (Brier, 1964) and meteoric dust (Adderley and Bowen, 1962) have been proposed as possible causes of the relationship between precipitation and the position of the moon. The relationship of these parameters to sunshine (cloudiness) might also be tested.

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