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**U.S. NAVAL STATION**  
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**Technical Note No. 5**

complete

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**Sunshine in Bermuda**

**By**

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## 1. INTRODUCTION

Bermuda's economy is largely based on tourists who come from the North American mainland. These tourists are attracted by the less extreme climatic conditions which prevail in a small island in mid ocean as compared with the continent. Especially in the winter half-year, the amount of daily sunshine is the element which most affects the comfort and pleasure of the visitors.

It is unfortunate, therefore, that although regular meteorological observations were begun in 1890 they were primarily for synoptic purposes and sunshine was not recorded. Instrumental observations of sunshine did not begin until thirty-seven years later on the 1st January, 1927.

These observations have been continued so that with the end of 1951 we have twenty-five years of records. It is the purpose of this note to summarise the data available.

## 2. RECORDING INSTRUMENT

The records discussed were taken with a standard Campbell Stokes Sunshine Recorder.

This consists essentially of a glass sphere used as a burning glass to focus the sun's rays on a curved card. The length of burn gives the duration of sunshine above the minimum intensity necessary to burn the card. This is stated to be about 0.25 calories per square centimetre per second under good conditions and twice as much when the card has been wet by rain. The length of the burn is measured in accordance with standard procedure and makes the figures comparable with those taken elsewhere with similar instruments.

However, when other types of recorder are used the records are not strictly comparable and the adjustments necessary to allow of comparison with records taken in the United States of America are discussed in section 10.

## 3. SITE

The records for the first years from 1st January, 1927, to 30th April, 1932, were made at Prospect Military Camp. Latitude  $32^{\circ}18'N.$ , Longitude  $64^{\circ}46'W.$  Up to the beginning of 1926 the meteorological observations at Prospect were made in the grounds of Observatory Cottage. However, during 1926 or 1927 some at least of the instruments were moved to a site at or near the Military Hospital. It is not known at which of these sites the sunshine recorder was erected but there is a post in the grounds of Observatory Cottage with a platform which may well have been for the sunshine recorder.

The actual cards from the recorder have been lost and we have only the daily totals as entered in the monthly summaries of observations kept by the Canadian Meteorological Department to which the Bermuda records were sent monthly by the observer at Prospect.

From the 1st May, 1932, the sunshine recorder has been erected on the South West corner of the parapet of Fort George, St. George's, Latitude 32°23'N., Longitude 64°41'W., at a height of 182 feet above mean sea level. All the original record cards are available and have been scaled in accordance with standard procedure.

Data on hourly values given in this note are based solely on the Fort George records, but with this exception, all values given have been computed using all the data available from both Prospect and Fort George as if it was for a single site.

Length of possible daily sunshine has been taken as that for Fort George being the interval between the times of sunrise and sunset.

#### 4. ANNUAL SUNSHINE

The main figures of annual sunshine are given in Table 1. With an average of 2,588 hours Bermuda has a normal amount for an oceanic location in this latitude.

	Average	Highest	Year	Lowest	Year
Total in hours.....	2588	2789	1927	2384	1930
Daily average in hours.....	7.08	7.64	1927	6.53	1930
Percentage of possible.....	58	63	1927	54	1930
Number of days with:—					
Some sunshine recorded.....	351	358	1944	340	1928
Four hours or more sunshine recorded.....	281	311	1927	260	1930
Eight hours or more sunshine recorded.....	173	209	1927	148	1940
Twelve hours or more sunshine recorded.....	29	43	1927	13	1930

TABLE 1. Annual Sunshine.

The extremes of 2,789 in 1927 and 2,384 in 1930 are, as is seen, very close to 200 hours above and below the average, but Table 2 which gives the frequency distribution by quintiles shows that in 60% of years the total lies between 2,525 and 2,659. A closer examination of figures for individual years shows that only in five years was the total outside the limits of 2,500 to 2,687 which, therefore, includes 80% of occasions.

	Limits in Hours	Range
Highest Quintile.....	2660 - 2789	129
Second Quintile.....	2607 - 2659	52
Third Quintile.....	2562 - 2606	44
Fourth Quintile.....	2525 - 2561	36
Lowest Quintile.....	2384 - 2524	140

TABLE 2. Frequency Distribution of Total Annual Sunshine.

It is likely, therefore, that only rarely will these absolute extremes be exceeded even over a long period. It is to be noted that both these extremes occurred in the first four years of the record when observations were being taken at Prospect.

There have not been less than 340 days with sunshine in any year, and the average number is 351. There are, on the average, 281 days with four hours, 173 with eight hours and 29 with twelve hours.

## 5. MONTHLY SUNSHINE

Values of monthly sunshine are given in Table 3. The lowest total comes, as is to be expected, in December, which has 152.5 hours, an average of 4.9 hours per day and 49% of the possible. January and February have greater absolute amounts, but only the same percentage of possible as December. In March the percentage of possible begins to increase and rises to the year's maximum of 70% in July, which has an average total of 305.4 hours or 9.9 hours per day. June, the month of the summer solstice, has only 60% of possible and is surpassed by August with 67%, and September with 64% in addition to July. November with 55% has the same percentage as October indicating a temporary halt in the fall to the winter minimum.

	AVERAGE			MAXIMUM				MINIMUM			
	Mthly Total Hrs.	Av. Dly Hrs.	% pos.	Mthly Total Hrs.	Av. Dly Hrs.	% pos.	Year	Mthly Total Hrs.	Av. Dly Hrs.	% pos.	Year
January.....	157.0	5.1	49	214.7	6.9	67	1950	110.8	3.6	35	1948
February....	153.7	5.4	49	195.3	7.0	63	1939	119.1	4.3	39	1941
March.....	194.6	6.3	53	238.1	7.7	64	1934	141.2	4.6	38	1930
April.....	226.3	7.5	58	273.6	9.1	70	1948	184.4	6.1	47	1949
May.....	254.3	8.2	59	304.5	9.8	71	1927	202.1	6.5	47	1951
June.....	258.5	8.6	60	296.4	9.9	69	1946	202.8	6.8	47	1927
July.....	305.4	9.9	70	358.4	11.6	82	1945	253.3	8.2	58	1939
August.....	278.8	9.0	67	325.7	10.5	79	1937	219.8	7.1	53	1929
September..	236.9	7.9	64	271.7	9.1	73	1933	181.6	6.1	49	1950
October.....	195.9	6.3	55	247.9	8.0	70	1949	160.8	5.2	46	1930
November..	174.0	5.8	55	228.8	7.6	72	1950	122.1	4.1	39	1931
December..	152.5	4.9	49	194.8	6.3	62	1927	82.2	2.7	26	1930

TABLE 3. Monthly Sunshine.

The sunniest month on record is July, 1945, which had 358.4 hours or 11.6 hours per day and 82% of possible. May and August have each had over 300 hours and with the exception of June which has had 69%, all months from April to November have had 70% or more on some occasions. December has the lowest maximum of 194.8 hours or 62% of possible. May and December are the only months whose maximum was recorded in 1927 which, as was shown earlier, was the sunniest year.

The dullest month on record is December, 1930, which had just over one-quarter of possible, giving an average of 2.7 hours per day and a total of 82.2 hours. July with a lowest of 58% and August with 53% are the only two months which have never had less than half possible, but except for December, 1930, no month has had less than 35%.

From April to September there has not been a month with an average of less than six hours per day.

The minima for March, October and December each occurred in the record dull year of 1930, while the June minimum was in 1927, the sunniest year.

	EXCESS OF ABSOLUTE MAXIMUM OVER AVERAGE		DEFICIT OF ABSOLUTE MINIMUM FROM AVERAGE		TOTAL RANGE		
	Hours	Percentage of Average	Hours	Percentage of Average	Hours	Percentage of Average	Percentage of Possible
January.....	57.7	36.8	46.2	29.4	103.9	66.2	32.6
February.....	41.6	27.1	34.6	22.5	76.2	49.6	24.7
March.....	43.5	22.4	53.4	27.4	96.9	49.8	26.1
April.....	47.3	20.9	41.9	18.5	89.2	39.4	23.0
May.....	50.2	19.7	52.2	20.5	102.4	40.2	23.9
June.....	37.9	14.7	55.7	21.5	93.6	36.2	21.9
July.....	53.0	17.4	52.1	17.1	105.1	34.5	24.1
August.....	46.9	16.8	59.0	21.2	105.9	38.0	25.6
September.....	34.8	14.7	55.3	23.3	90.1	38.0	24.2
October.....	52.0	26.5	35.1	17.9	87.1	44.4	24.6
November.....	54.8	31.5	51.9	29.8	106.7	61.3	33.8
December.....	42.3	27.7	70.3	46.1	112.6	73.8	36.1

TABLE 4. Ranges of total monthly sunshine.

Table 4 gives the deviations of extremes of total sunshine in each month from the average, in hours and as percentages of average and of possible.

The greatest variation from average both in hours and percentages of average is the minimum for December which was 70 hours and 46% below average and made the extreme range in December of 112.6 hours almost 74% of average. The greatest departure of maximum was in January where the sunniest occasion, 1950, exceeded the average by 58 hours or 37%.

The maxima in June and September show the smallest deviations of 14.7% while July has the smallest deviation of minimum with 17.1%.

The total range considered as a percentage of average is least in July with 34.5% and from June to September each month has 38% or less, while the highest values are shown in November, December and January, each of which has a range of over 60% of average.

Taken as a percentage of possible, November, December and January with over 32% each, again show the greatest variation while June with 22% shows the least.

Absolute Minimum	Fourth Quintile	Third Quintile	Second Quintile	First Quintile	Absolute Maximum
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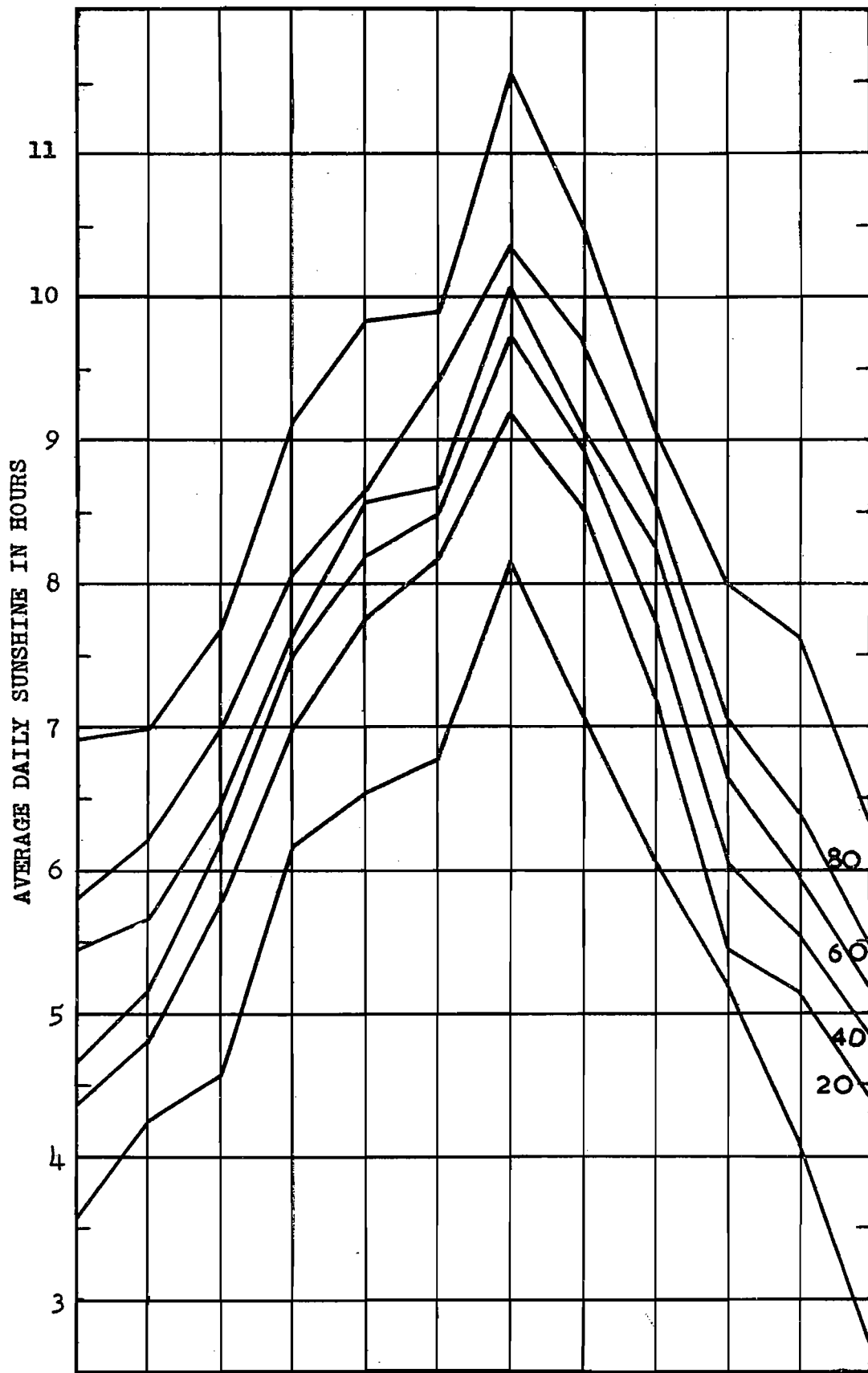
## 5.1 FREQUENCY OF VARIOUS TOTALS OF MONTHLY SUNSHINE

The frequency of occurrence of different totals in each month is shown in Table 5, which gives the limits of the quintiles in monthly totals and also daily average, and in Figure 1 where daily average quintiles are plotted.



		Absolute Maximum	First Quintile	Second Quintile	Third Quintile	Fourth Quintile	Absol Minim
January.....	Total Daily	214.7 6.93	179.7 5.80	168.3 5.43	144.9 4.67	134.9 4.35	110.8 3.57
February.....	Total Daily	195.3 6.98	173.6 6.20	158.3 5.65	144.4 5.14	134.3 4.80	119.1 4.25
March.....	Total Daily	238.1 7.68	215.7 6.96	199.5 6.44	190.8 6.15	177.7 5.73	141.2 4.55
April.....	Total Daily	273.6 9.12	241.9 8.06	229.3 7.64	224.8 7.49	208.9 6.96	184.4 6.15
May.....	Total Daily	304.5 9.82	267.9 8.64	265.3 8.56	253.6 8.18	239.7 7.73	202.1 6.52
June.....	Total Daily	296.4 9.88	281.9 9.40	259.7 8.66	253.8 8.46	245.1 8.17	202.8 6.76
July.....	Total Daily	358.4 11.56	319.8 10.32	312.5 10.08	301.5 9.73	285.3 9.20	253.3 8.17
August.....	Total Daily	325.7 10.50	300.7 9.70	281.7 9.09	276.7 8.93	265.3 8.56	219.8 7.09
September.....	Total Daily	271.7 9.06	257.3 8.58	247.7 8.26	231.9 7.73	215.9 7.20	181.6 6.05
October.....	Total Daily	247.9 8.00	218.5 7.05	205.3 6.62	187.5 6.05	169.1 5.45	160.8 5.19
November.....	Total Daily	228.8 7.63	191.9 6.40	178.0 5.93	165.9 5.53	154.3 5.14	122.1 4.07
December.....	Total Daily	194.8 6.28	169.2 5.46	159.4 5.14	149.6 4.82	135.7 4.38	82.2 2.65

TABLE 5. Frequency Distribution of Total Monthly Sunshine. Limits of Quintiles in monthly totals and average daily sunshine.



JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig 1. Frequency distribution of total monthly sunshine given by Quintiles of Average Daily Sunshine each month. Top and bottom curves give respectively the highest and lowest values recorded. Other curves give the limits of 20, 40, 60, 80% of cases.

It is seen that in most months the range of the central 60% is little more than that of each extreme 20% and varies from 0.9 hours in May to 1.6 hours in October.

The central 20% shows its maximum width in January, with 0.8 hours and October with 0.6 hours, but most of the other months have a range of less than 0.3 hours.

## 6. QUARTER MONTHLY SUNSHINE

In order to determine the values for periods of approximately a week each month was divided into four parts as follows:—

Months with 31 days.....	1-8, 9-16, 17-23, 24-31
Months with 30 days.....	1-8, 9-15, 16-23, 24-30
February.....	1-7, 8-14, 15-21, 22-29

The average daily sunshine and the percentage of possible in these quarters are given in Table 6 and plotted in Figure 2.

	Average Daily Sunshine in Hours				Percentage of Possible Sunshine			
	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
January.....	5.1	4.9	4.8	5.5	50	48	46	52
February.....	5.3	5.6	5.3	5.6	50	51	47	49
March.....	5.9	6.0	6.2	7.0	51	50	52	57
April.....	7.3	7.5	7.5	7.9	58	58	57	59
May.....	7.8	8.2	8.9	7.9	58	60	64	57
June.....	8.0	8.9	8.6	9.0	57	63	60	63
July.....	9.5	9.9	10.2	9.8	67	70	73	71
August.....	9.6	8.8	9.0	8.7	70	65	68	67
September.....	8.7	8.0	7.8	7.1	68	64	63	59
October.....	6.1	6.1	6.4	6.7	52	53	57	61
November.....	6.4	6.3	5.6	4.8	59	59	54	47
December.....	5.2	5.1	4.5	4.8	51	51	45	48

TABLE 6. Average sunshine in quarter months.

The sunniest period of the year is the third quarter of July with 10.2 hours a day which is 73% of possible while the dullest is the third quarter of December with 4.5 hours a day and 45% of possible.

From the latter part of November to mid March the percentage of possible varies between the 45% minimum and 52%. In the third quarter of March a rise begins to a subsidiary maximum of 64% and 8.9 hours a day in the third quarter of May. There is a sharp fall in the last quarter of May which lasts through the first quarter of June, each having only 57% of possible and an hour a day less than the earlier period. The rise is resumed in the second quarter of June and after reaching the year's maximum in July the curve turns sharply down till mid August.

It remains steady through the first week of September, and then drops to a subsidiary minimum in the first half of October which is only slightly above the winter months in percentage of possible. The next four weeks show an appreciable rise with about 60% of possible and  $6\frac{1}{2}$  hours per day, but in the last half of November there is a rapid fall to the winter values.

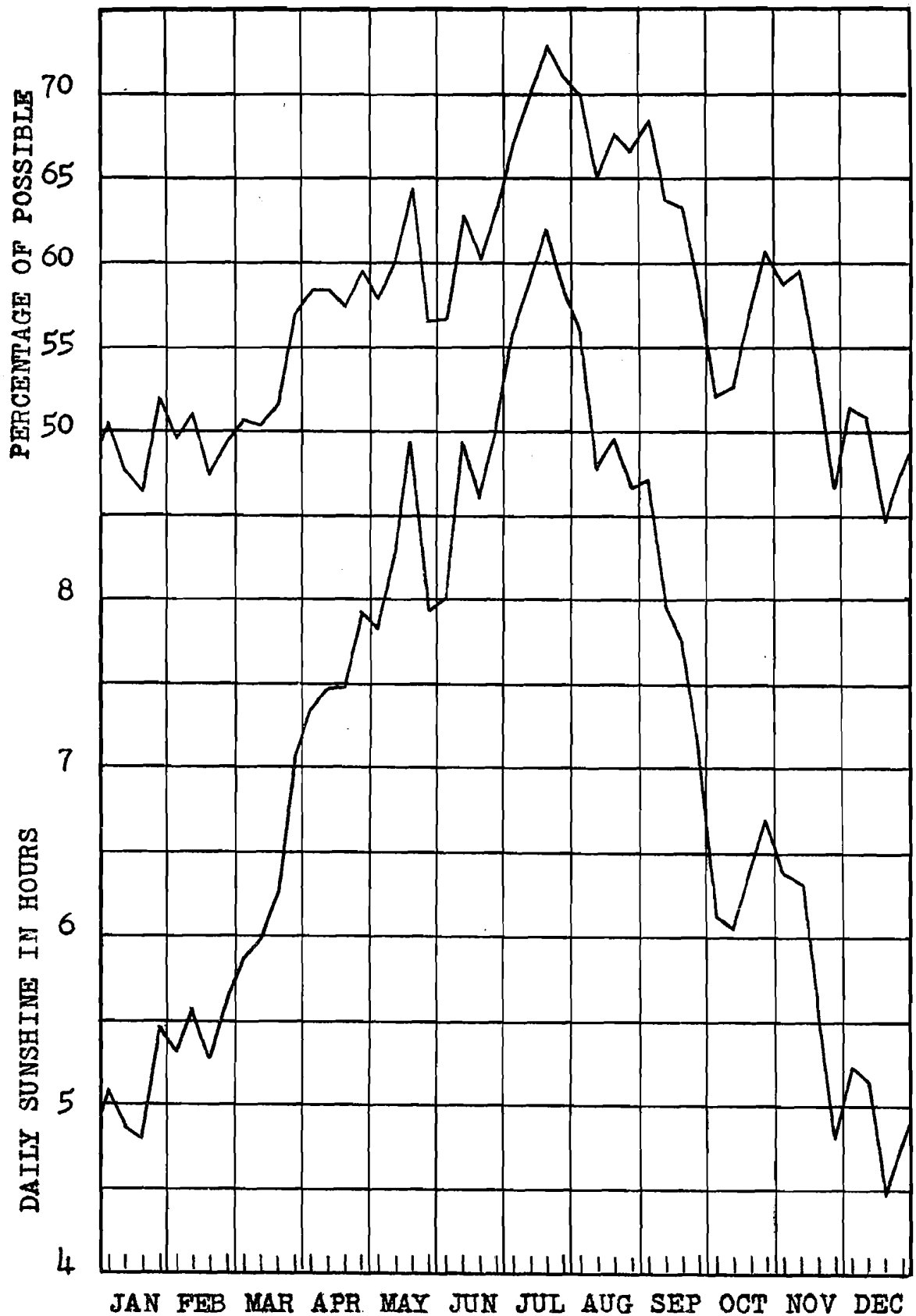


Fig 2. Average daily sunshine and percentage of possible in each quarter month.

## 7. FREQUENCY DISTRIBUTION OF DAILY SUNSHINE DURING THE YEAR

The frequency of days with different amounts of daily sunshine is shown in Table 7 and Figure 3.

It is seen that the most frequent range is 9 to 10 hours which occurs on 41 days per year while 8 to 9 hours, which is recorded on 39 days, is almost as common.

Days Total Hours	Average Number per Year	Minimum Number Recorded	Year	Maximum Number Recorded	Year	Number in 1927	Number in 1930
0.0	14	8	1933, 44	26	1928	17	19
0.1- 0.9	18	3	1927	30	1930	3	30
1.0- 1.9	14	6	1927, 28	26	1933	6	13
2.0- 2.9	18	4	1933	26	1943	12	22
3.0- 3.9	20	14	1942	27	1935, 40	16	21
4.0- 4.9	20	14	1943, 47	29	1928, 35	15	15
5.0- 5.9	23	15	1931, 41, 50	31	1934	22	23
6.0- 6.9	31	21	1933	44	1932	34	32
7.0- 7.9	34	24	1943, 48	52	1931	31	34
8.0- 8.9	39	23	1940	81	1927	81	40
9.0- 9.9	41	31	1940, 51	53	1950	45	45
10.0-10.9	33	21	1927	48	1939	21	24
11.0-11.9	31	19	1927	45	1945	19	34
12.0-12.9	26	13	1930	36	1934	35	13
13.0-13.9	3	0	1929, 30) 1931, 42)	9	1928, 41	8	0

TABLE 7. Yearly frequency of days with various totals of sunshine.

Each hour range from 6 to 12 hours, occurs on more than 30 days and this whole interval covers 209 days per year.

There have not been more than 26 sunless days in any year and there have been as few as 8. The average over the 25 years is 14. Thirteen hours or more occurs on at least one day in four years out of five, and there has been 9 days on two occasions making an average of 3 a year.

The figures for 1927 and 1930 are also given as these years had respectively the highest and the lowest total annual sunshine on record.

It is seen that the number of days with from four to eight hours and from nine to eleven hours sunshine is almost identical in the two years. The sunny year, however, was marked by having twice as many days with eight to nine hours, and only one-tenth as many with 0.1 to 0.9 hours.

The number of sunless days was almost the same in the two years, but the dull year had more than twice as many with less than four hours.

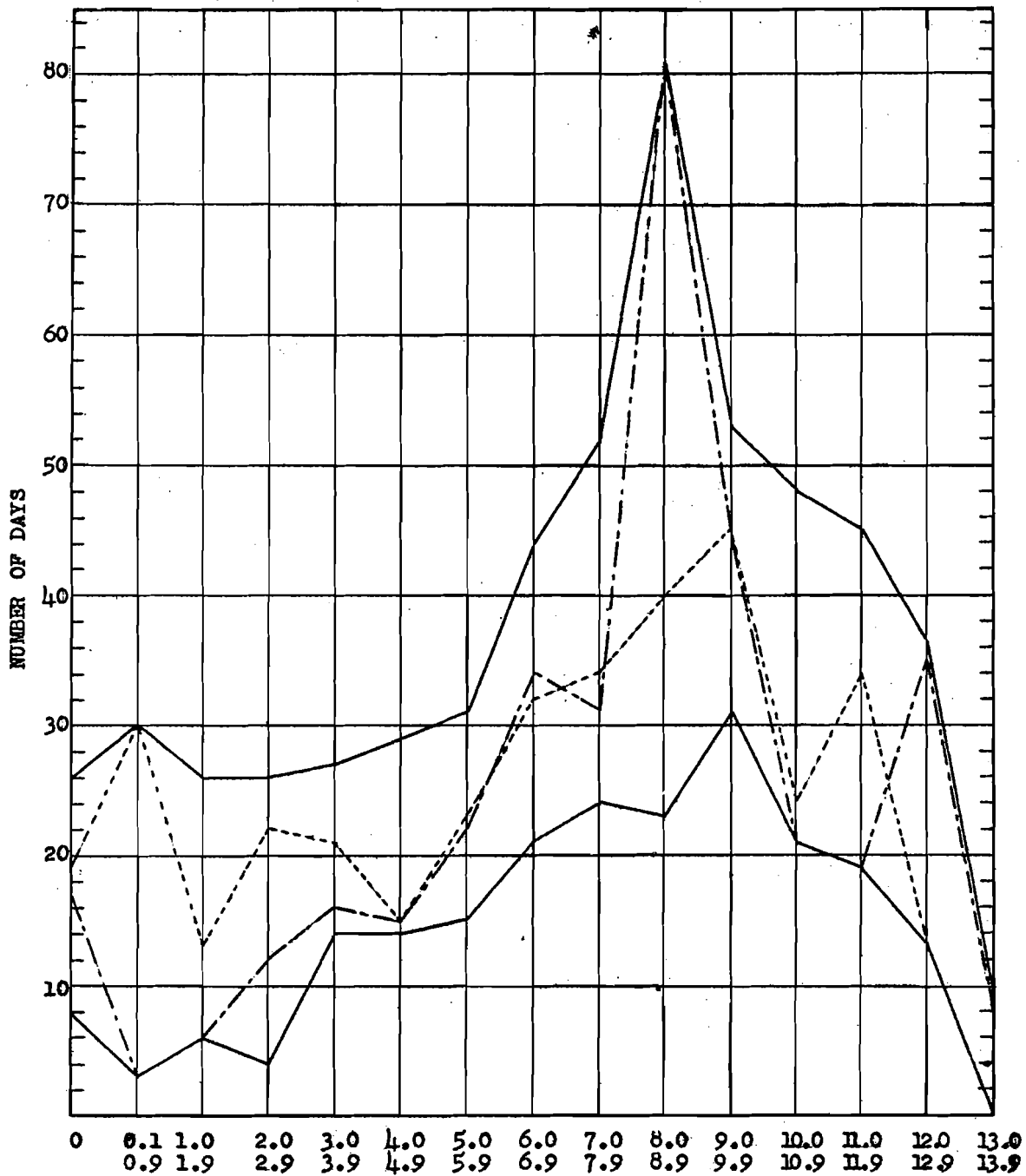


Fig 3. Total number of days per year with sunshine in limits stated. Dotted line 1930, dulllest year; Dash, dot line 1927, sunniest year. Solid line highest and lowest numbers ever recorded.



At the top of the range a subsidiary maximum occurs from eleven to twelve hours for the dull year and twelve to thirteen hours for the sunny, so that in the dull year there were 34 days with 11 to 11.9 hours compared with only 19 days in the sunny year. However, in the 12 to 12.9 hour interval the sunny year with 35 days had nearly three times the 13 days in the dull year.

In the dull year no days reached 13 hours, while eight did so in the sunny year.

### 7.1. FREQUENCY DISTRIBUTION OF DAILY SUNSHINE IN EACH MONTH

The percentage of days in each month with total sunshine in intervals of one hour from zero to the maximum recorded are given in Table 8. The hour with the greatest frequency is in all months nearer the highest values on the monthly range, this being most pronounced in the summer months where the peak of the frequency curve is much sharper than in the winter. The interval with the greatest frequency has the lowest values in February in which 14.6% or 1/7th of the days have 7-8 hours. In May, June and July days with 12-13 hours sunshine are the most common, over one-quarter of the days in July falling in this interval.

HOURS	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
0.0.....	5.4	4.4	5.5	3.3	4.3	2.1	1.2	1.2	2.4	5.7	6.4	4.5
0.1 - 0.9.....	7.9	5.9	5.4	3.9	4.0	4.5	1.0	2.6	2.9	6.8	5.6	8.6
1.0 - 1.9.....	6.3	4.9	3.7	2.7	3.1	3.1	1.7	1.8	2.9	4.5	5.5	6.1
2.0 - 2.9.....	7.6	8.2	4.5	3.3	3.2	3.9	2.2	3.2	3.7	5.3	7.1	8.1
3.0 - 3.9.....	8.9	7.5	6.2	5.7	3.9	2.5	3.2	3.2	3.6	6.2	4.9	9.6
4.0 - 4.9.....	8.4	10.5	6.7	4.8	4.8	2.5	2.1	3.1	3.5	3.9	5.2	10.7
5.0 - 5.9.....	12.4	8.8	7.2	4.0	5.2	4.5	4.0	3.7	3.3	4.8	6.9	9.8
6.0 - 6.9.....	11.1	13.7	9.9	8.3	5.3	4.9	3.0	4.6	7.7	9.2	11.3	12.8
7.0 - 7.9.....	12.1	14.6	12.3	9.9	5.5	6.1	3.4	6.1	7.9	9.2	13.6	11.7
8.0 - 8.9.....	12.6	10.1	13.3	11.5	6.7	6.1	5.9	7.5	9.6	14.1	16.6	12.9
9.0 - 9.9.....	6.8	7.6	15.5	11.6	8.3	10.1	7.7	9.2	19.2	18.1	14.9	5.0
10.0 - 10.9.....	0.4	3.8	8.1	14.0	9.8	13.6	11.4	13.8	21.3	12.1	1.9	
11.0 - 11.9.....			1.8	13.3	16.1	15.3	20.4	23.7	11.2	0.3		
12.0 - 12.9.....				3.7	18.6	17.2	27.3	15.6	0.5			
13.0 - 13.9.....					1.3	3.5	5.5	0.6	0.1			

TABLE 8. Percentage of days with total sunshine within limits given.

Table 9 and Figure 4 give the amounts of sunshine which are exceeded on 10, 20, 40, 60, 80 and 90% of days. It is seen that in each month of the year 10% of days have at least 8.5 hours while from May to August there is twelve hours or more on the same percentage of occasions.

Over  $7\frac{1}{2}$  hours sunshine is recorded on 20% of days in each month, with over nine hours in March to October and over  $11\frac{1}{2}$  hours in May to August.

On 40% of days in each month there are over six hours, with over nine hours in April to September.

	Highest Decile	QUINTILES				Lowest Decile
		1	2	3	4	
January.....	8.7	7.9	6.2	4.3	2.0	0.5
February.....	9.1	8.0	6.6	4.8	2.5	0.9
March.....	9.9	9.2	7.8	6.0	3.0	0.7
April.....	11.4	10.7	9.1	7.3	4.1	1.9
May.....	12.4	11.9	10.5	8.0	4.2	1.4
June.....	12.5	11.9	10.6	8.9	5.2	2.0
July.....	12.7	12.4	11.5	10.3	7.4	4.2
August.....	12.3	11.7	10.9	9.2	6.2	3.3
September.....	11.1	10.5	9.6	8.1	5.2	2.4
October.....	10.1	9.5	8.2	6.2	2.5	0.6
November.....	9.4	8.7	7.4	5.7	2.2	0.6
December.....	8.5	7.7	6.1	4.2	2.0	0.6

TABLE 9. Frequency distribution of daily sunshine. Table gives lower limits of values recorded in the top 10%, 20%, 40%, 60%, 80% and 90% of days.

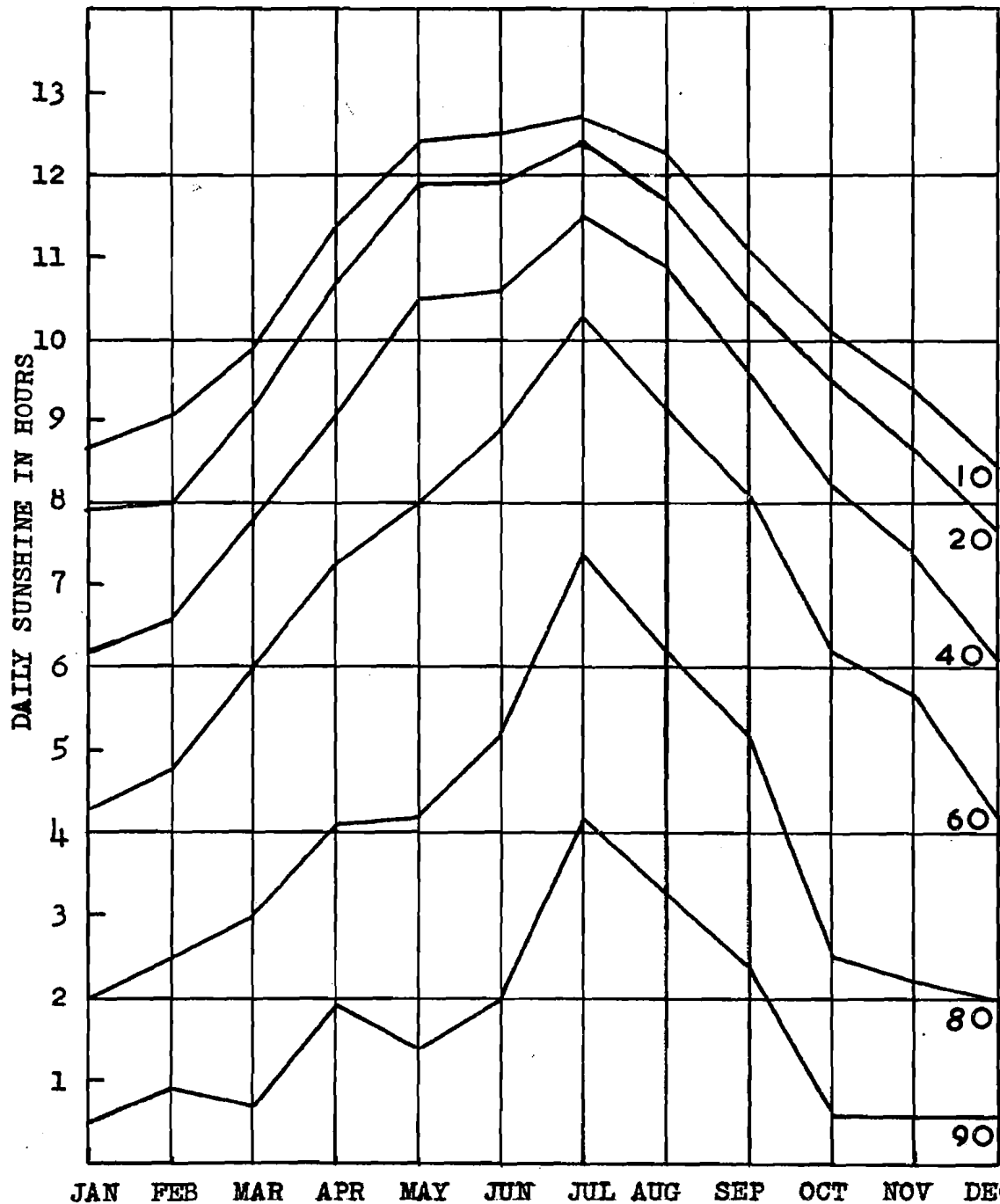


Fig 4. Amounts of sunshine per day reached on 10, 20, 40, 60, 80 and 90% of days in each month.

In each month 60% of days have over four hours, while in May to September over eight hours is recorded on 60% of days.

Considering the lower values we see that in October to March, 20% of days do not exceed three hours and 10% of days have less than one hour each. In July, 80% of days have more than 7 hours and 90% more than 4 hours.

## 7.2. RANGES OF DAILY SUNSHINE OBSERVED ON 25, 50 and 75% OF DAYS IN EACH MONTH

Table 10 gives for each month the smallest ranges of values of daily sunshine which include 25, 50 and 75% of days, and the data is given as a block diagram in Figure 5.

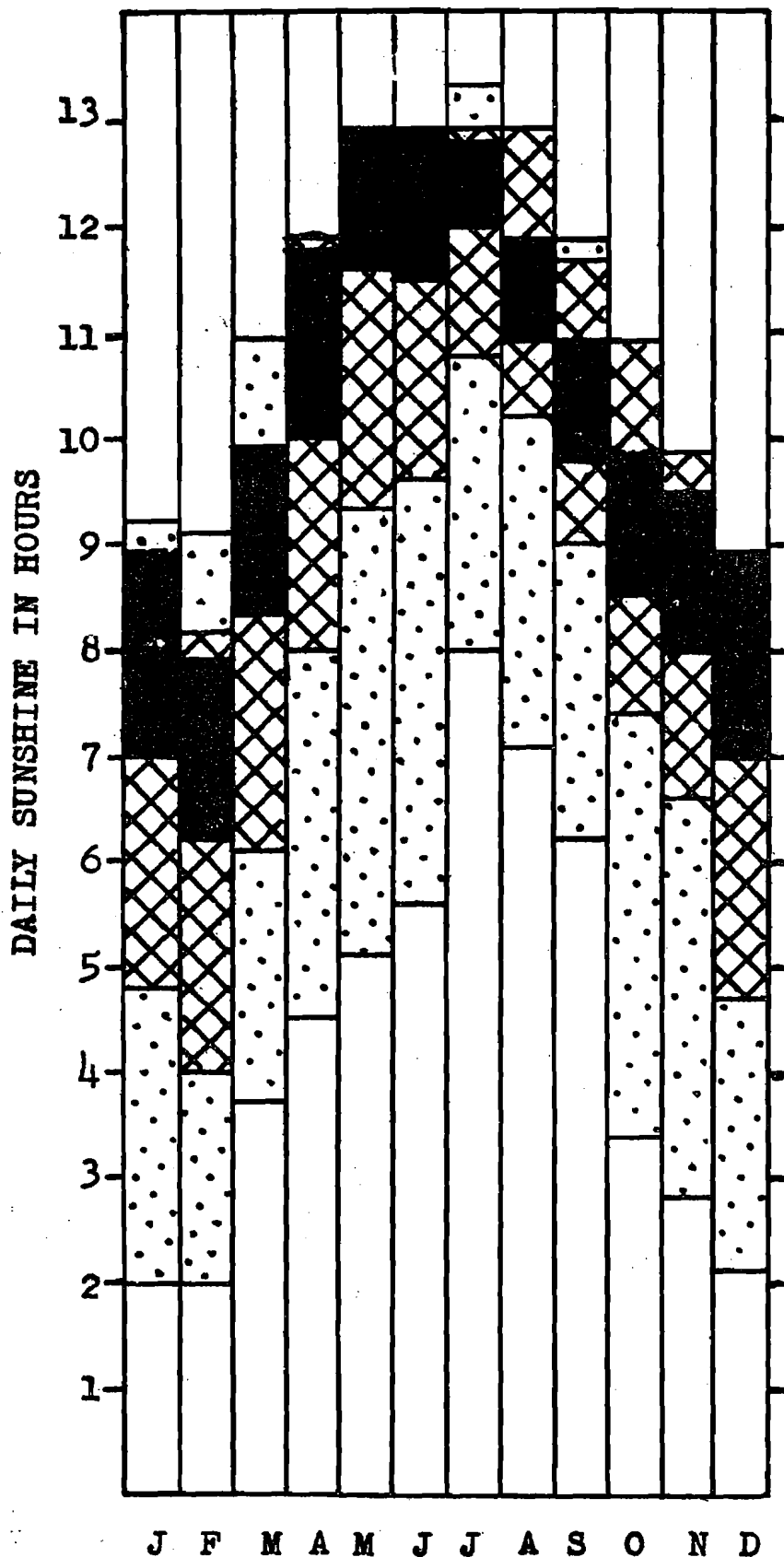
Percentage of days	25%	50%	75%
January.....	7.0 - 8.9	4.8 - 8.9	2.0 - 9.2
February.....	6.2 - 7.9	4.0 - 8.1	2.0 - 9.1
March.....	8.3 - 9.9	6.1 - 9.9	3.7 - 10.9
April.....	10.0 - 11.7	8.0 - 11.9	4.5 - 11.9
May.....	11.6 - 12.9	9.3 - 12.9	5.1 - 12.9
June.....	11.5 - 12.9	9.6 - 12.9	5.6 - 12.9
July.....	12.0 - 12.8	10.8 - 12.9	8.0 - 13.3
August.....	10.9 - 11.9	10.2 - 12.9	7.1 - 12.9
September.....	9.8 - 10.9	9.0 - 11.7	6.2 - 11.9
October.....	8.5 - 9.9	7.4 - 10.9	3.4 - 10.9
November.....	8.0 - 9.5	6.6 - 9.9	2.8 - 9.9
December.....	7.0 - 8.9	4.7 - 8.9	2.1 - 8.9

TABLE 10. Smallest Ranges of daily sunshine which include 25%, 50% and 75% of days in each month.

As the figures of Table 8 suggest, the limits of 25% are near the top of the total range but except in May and June do not extend to quite the high values included in 50% and 75% of days.

In the winter months a range of two hours includes 25% of days with the range decreasing to about one hour in summer.

In July 50% of days extend over a range of 2.2 hours while in the three winter months the range of 4.2 and 4.3 hours is almost twice as much.



J F M A M J J A S O N D  
 Fig 5. Smallest ranges of daily sunshine which include 25, 50 and 75% of days each month. 25% Black; 50% Black and Cross Lines; 75% Black, Cross Lines and Dots.

July has 75% of days inside a range of 5.3 hours while August and September also extend over less than 6 hours. December has a range of 6.8 hours and all other months over 7 hours with the maximum of 7.8 and 7.5 hours in May and October respectively.

In general the increased number of days in 50% and 75% comes from an extension downwards to lower values of daily sunshine than are included in 25%. There are, however, small upward increases.

### 7.3. FREQUENCY DISTRIBUTIONS OF DAILY SUNSHINE IN THE FIVE SUNNIEST AND IN THE FIVE DULLEST OCCASIONS OF EACH MONTH

Table 11 gives the distribution of days in the five occasions of each month with highest total sunshine and on the five occasions with lowest totals. The figures are to be compared with Table 9 which gives the corresponding distribution for the average months.

The difference between sunny and dull occasions of a month is seen to be mainly due to changes in the sunshine recorded on the less sunny days. This is more marked in the summer months than in winter.

In a sunny July the sunniest 10% of days have each above 12.8 hours and in a dull month only 0.3 hours less. However, the dullest 10% of days are all below 1.7 hours daily sunshine in a dull July, while in a sunny month the limit is 8.5 hours, or five times as great.

Similarly, there is a difference between sunny and dull Julys of only 0.5 hours in the lower limits of the sunniest 20% of days, but the upper limit of the least sunny 20% of days, which is 9.9 hours in sunny months, is reduced to 4.5 hours in dull months, a difference of 5.4 hours.

		Highest Decile	QUINTILES				Lowest Decile
			1	2	3	4	
January	High	9.2	8.6	7.4	6.1	3.1	1.1
	Low	7.5	6.4	4.9	3.3	0.9	0.1
February	High	9.8	9.1	7.7	6.3	3.9	2.7
	Low	7.8	7.1	5.4	3.7	1.7	0.6
March	High	10.4	9.7	8.6	7.3	4.7	1.5
	Low	9.5	8.7	6.7	4.4	1.1	0.3
April	High	11.6	11.0	10.1	8.3	6.4	3.6
	Low	10.9	10.0	8.4	6.1	2.1	0.5
May	High	12.7	12.4	11.3	9.2	5.3	3.1
	Low	11.8	11.2	9.0	6.3	2.0	0.4
June	High	12.7	12.3	11.3	10.1	7.4	3.4
	Low	12.2	11.4	9.6	6.9	3.1	0.7
July	High	12.8	12.6	12.1	11.3	9.9	8.5
	Low	12.5	12.1	10.9	8.7	4.5	1.7
August	High	12.4	11.9	11.2	10.2	8.3	6.6
	Low	11.8	11.4	10.1	7.4	3.8	2.3
September	High	11.1	10.7	10.0	9.0	6.9	5.2
	Low	10.6	10.0	8.6	6.3	2.9	0.6
October	High	10.5	10.1	9.1	7.7	4.2	2.4
	Low	9.8	9.2	7.0	3.9	0.8	0.0
November	High	9.6	9.2	8.4	7.1	4.3	2.0
	Low	8.8	8.1	6.7	3.5	0.8	0.0
December	High	8.8	8.2	7.0	5.7	3.4	2.0
	Low	8.0	6.7	4.7	2.8	0.7	1.0

TABLE 11. Frequency distribution of daily sunshine in the five sunniest and the five dull-est occasions of each month. High values are average of the five sunniest months and low values are the average of the five dullest months.

On the other hand in January and February there is about two hours difference from sunny to dull occasions in the lower limit of the sunniest 20% of days and also in the upper limit of the dullest 20%.

In the least sunny occasions the dullest 10% of days have zero, or close to zero, sunshine from October to January and less than 45 minutes in all other months except July and August.

Even in the dullest occasions 10% of days in every month have over 7½ hours and over 10 hours from April to September, while 40% have more than 6.7 hours from March to November and at least 4.7 hours in the winter months.

## 8. HOURLY SUNSHINE

Table 12 gives for each month the percentage of possible sunshine which was recorded in each hour of local apparent time at Fort George. Hourly records for Prospect are not available.

Owing to Bermuda standard time being set four hours behind Greenwich Mean Time when the actual longitude is 64°41' West, apparent time is on the average 19 minutes behind standard.

The average sunshine in each hour was calculated also for each quarter month and from the results Figure 6 has been drawn to give the isopleths of 5 to 50 minutes per hour throughout the year.

Hour	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec
4-5					0.0	0.0	0.0					
5-6			0.0	3	10	17	24	13	0.0			
6-7	0.3	4	12	33	52	57	71	62	33	14	1	0.0
7-8	25	33	47	56	63	67	78	75	66	49	34	18
8-9	48	51	59	63	69	72	81	79	73	62	56	48
9-10	57	56	64	68	72	74	83	80	75	66	62	56
10-11	60	63	67	73	73	76	84	80	76	67	68	59
11-12	61	62	68	74	74	77	81	79	77	69	69	62
12-13	60	63	68	74	74	75	81	79	77	68	68	60
13-14	59	63	66	73	73	74	81	78	75	67	66	61
14-15	54	58	64	71	71	73	79	76	74	64	63	57
15-16	48	52	60	67	68	72	79	74	69	60	55	48
16-17	28	37	50	60	62	65	75	69	62	50	36	23
17-18	0.7	7	15	38	51	56	66	55	31	14	5	0.0
18-19			0.0	4	14	19	21	13	0.5			
19-20					0.0	0.0	0.3					

TABLE 12. Sunshine actually recorded in each hour local apparent time as a percentage of possible in that hour. Fort George May, 1932 - December, 1951.



The diagram shows that the highest values are in the third quarter of July, which has over 50 minutes per hour from 7.30 a.m. to 2.15 p.m. In the third quarter of August there is also 50 minutes in the hour centered on 9 a.m.

From the last quarter of March to the end of September there is 40 minutes per hour from 9 a.m. to 3 p.m. and 30 minutes per hour from 7.30 a.m. to 4.30 p.m. Throughout the year there is 30 minutes per hour from 9.30 a.m. to 1.30 p.m.

A number of subsidiary maxima occur, the most noticeable being the 3rd quarter of May, which has 45 minutes per hour from 8.30 a.m. to 1.30 p.m. and the first quarter of November with 45 minutes per hour from 10 a.m. to 1.30 p.m.

The first quarters of January and of March also show maxima with 40 minutes per hour from noon to 1.30 p.m. and 11 a.m. to 1.30 p.m. respectively.

The figure also shows the corresponding periods which are rather duller than those coming before and after. The most marked is the first quarter of October, but the third quarter of December and middle of January are also indicated as periods with relative minima.

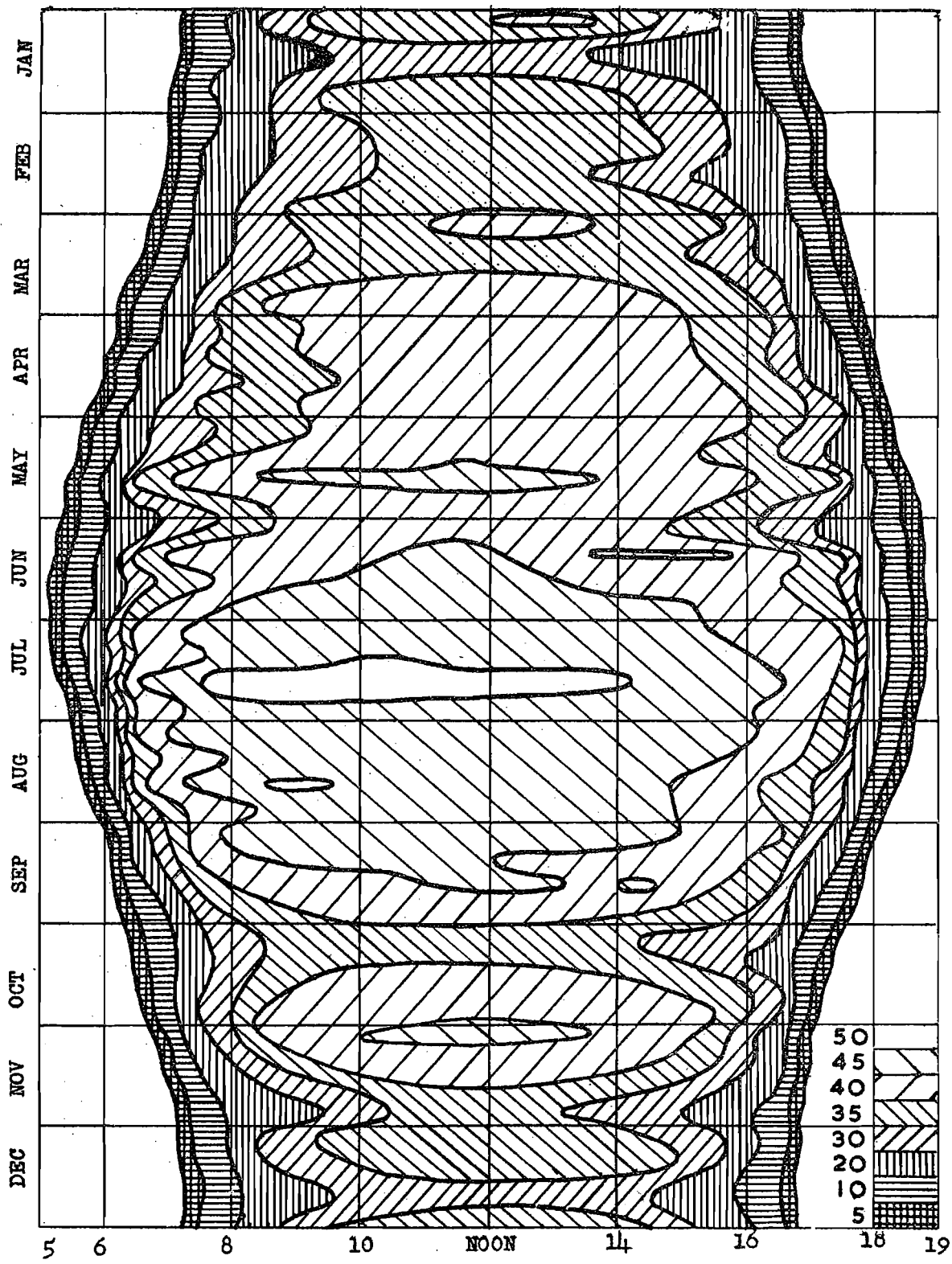


Fig 6. Average amount of sunshine in minutes per hour recorded in each hour throughout the year.

## 8.1. FREQUENCY OF VARIOUS AMOUNTS OF SUNSHINE IN EACH HOUR

Tables 13, 14 and 15, give by months the percentage of days which have respectively 60 minutes, 30 minutes or more, and at least some sunshine in separate hours of the day.

The tables show that the sunniest times are from 9 a.m. to 11 a.m. in July when there is some sunshine on 11 days out of 12, at least 30 minutes on six days out of seven and continuous sunshine on seven days out of ten.

In July from 7 a.m. to 4 p.m., and August from 8 a.m. to noon each hour has some sunshine on nine days out of ten, and at least 30 minutes on four days out of five. Except for the first hour in each case the same periods in these two months have 60 minutes sunshine in each of these hours on 65% of occasions, i.e. almost two days out of three.

Hours L. A. T.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5-6							0.2					
6-7				7	27	30	44	29	1			
7-8	1.4	9	18	32	46	45	61	59	42	24	4.3	
8-9	22	24	36	41	52	53	65	63	54	42	33	22
9-10	32	29	42	47	59	57	70	67	60	47	42	33
10-11	38	36	45	55	58	63	73	65	61	50	48	38
11-12	37	36	48	58	60	64	69	65	61	52	50	38
12-13	36	38	48	57	60	61	69	64	59	51	49	36
13-14	34	36	44	57	58	60	67	64	57	48	45	35
14-15	30	31	43	53	59	57	66	61	55	43	42	32
15-16	25	25	36	46	51	53	65	56	48	39	32	23
16-17	2.7	11	21	37	42	45	54	49	38	23	10	0.2
17-18				11	26	30	39	25	1			

TABLE 13. Percentage of days with sixty minutes sunshine recorded in hours stated Fort George, 1932 to 1951.

Hours L. A. T.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5-6					5	16	23	1.9				
6-7		0.2	9	35	57	62	76	66	38	1.8		
7-8	26	33	50	58	67	70	82	78	70	52	35	16
8-9	51	55	63	66	73	75	83	82	76	65	60	50
9-10	60	59	69	73	76	77	85	82	77	69	66	60
10-11	63	67	71	77	75	78	85	82	79	71	70	62
11-12	64	67	71	77	76	78	83	82	79	72	73	65
12-13	65	66	72	77	77	76	83	82	80	72	72	63
13-14	64	67	70	76	75	77	82	80	77	69	69	65
14-15	57	61	68	75	72	76	82	79	77	67	67	60
15-16	52	56	64	69	70	75	81	78	72	63	59	50
16-17	30	41	54	63	64	68	79	73	66	53	40	23
17-18		0.4	13	42	54	59	72	59	34	4.5		
18-19				0.5	7	18	17	1.8				

TABLE 14. Percentage of days with thirty minutes or more sunshine in hour stated Fort George 1932 to 1951.

Hours L. A. T.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5-6				7.6	37	50	67	42				
6-7	0.2	14	40	59	73	77	86	83	69	37	3.5	
7-8	57	63	73	76	79	83	90	88	82	72	69	56
8-9	73	77	78	81	84	86	92	90	87	78	77	75
9-10	78	78	81	86	85	87	92	90	88	81	79	78
10-11	80	85	83	87	87	86	92	90	88	82	83	80
11-12	82	85	84	87	87	89	90	90	89	81	85	82
12-13	80	85	85	87	84	87	90	89	89	82	83	81
13-14	78	82	82	87	84	87	91	89	88	83	83	83
14-15	76	81	82	86	83	87	90	88	87	80	81	78
15-16	71	76	79	84	81	86	91	88	84	78	74	73
16-17	58	66	73	78	79	82	89	86	80	71	64	56
17-18	1.2	20	44	65	72	78	83	78	66	39	10	
18-19				10	45	51	62	39	1			
19-20							0.2					

TABLE 15. Percentage of days with some sunshine recorded in hours stated. Fort George 1932 to 1951.

In three days out of four some sunshine is recorded in each hour in an interval which increases from the limits of 9 a.m. to 3 p.m. in January to 6 a.m. to 6 p.m. in June, July and August.

There is at least 30 minutes sunshine in certain hours in two days out of three from February to November inclusive. The interval is 10 a.m. to 2 p.m. in February, increases to 6 a.m. to 6 p.m. in July, and then decreases again to 9 a.m. to 3 p.m. in November. In December and January there is at least 30 minutes per hour from 10 a.m. to 2 p.m. only slightly less frequently than in February.

There is continuous sunshine in each hour on one day out of three from a minimum of 10 a.m. to 2 p.m. in December, January and February to a maximum of 6 a.m. to 6 p.m. in July.

## 9. EXTREME TOTALS IN PERIODS OF ONE TO TWENTY-EIGHT DAYS IN A YEAR

Tables 16 and 17 give highest and lowest totals recorded annually in periods up to 28 days. It is seen that in the normal year there is one week with an average of 12.2 hours per day and another with only 2.0 hours per day while one four week period averages 10.7 hours a day and another only 4.3 hours.

	Average Maximum		Absolute Maximum			Lowest Maximum		
	Total	Per day	Total	Per day	Date	Total	Per day	Date
1 Day....	13.1	13.1	13.4	13.4	24.6.38 25.6.38 11.7.47	12.7	12.7	'30, '31
2 Days..	25.8	12.9	26.8	13.4	24.6.38	24.2	12.1	1931
3 Days..	38.2	12.7	40.0	13.3	25.6.38	36.1	12.0	1931
7 Days..	85.3	12.2	90.9	13.0	23.6.38	79.5	11.4	1931
14 Days..	160.9	11.5	173.8	12.4	12.7.35	144.4	10.3	1932
28 Days..	298.9	10.7	339.6	12.1	10.7.49	265.3	9.5	1940

TABLE 16. Maximum sunshine recorded in periods of one to twenty-eight days during a year. Dates give first day of period.

There has not been a year in which at least one week did not average up to 11.4 hours a day and another as low as 3.7 hours daily, or one period of four weeks with 9.5 hours a day and another down to 5.5 hours per day.

Considering periods of two weeks we see there has not been a year when one such period did not average 10.3 hours a day and another down to 5.3 hours daily.

The highest total in 14 days was 173.8 hours in July, 1935, an average of 12.4 hours a day, and the highest in 28 days 339.6 hours, 12.1 hours a day, in July, 1949.

	Average Minimum		Absolute Minimum			Highest Minimum		
	Total	Per Day	Total	Per Day	Date	Total	Per Day	Date
1 Day....	0.0	0.0	0.0	0.0	Many	0.0	0.0	Many
2 Days..	0.2	0.1	0.0	0.0	Many	1.2	0.6	Jan/38
3 Days..	1.0	0.3	0.0	0.0	7 cases	4.1	1.4	Jan/35
7 Days..	13.8	2.0	1.1	0.2	3.11.31	25.9	3.7	Apr/33
14 Days..	46.9	3.3	26.9	1.9	17.12.30	74.4	5.3	Feb/33
28 Days..	120.4	4.3	70.1	2.5	3.12.30	154.2	5.5	Jan/27

TABLE 17. Minimum sunshine recorded in periods of one to twenty-eight days during a year. Dates give first day of period.

The lowest in 14 days was 26.9 hours, 1.9 hours a day, in December, 1930, and the lowest in 28 days, 70.1 hours, or 2.5 hours a day, also in December, 1930.

### 9.1. EXTREME TOTALS IN PERIODS OF ONE TO SEVEN DAYS IN EACH MONTH

The highest and lowest total amounts which are, on the average, recorded in periods of 1, 2, 3 and 7 days in each month, are given in Table 18, while tables 19 and 20 give the absolute highest and absolute lowest totals which have been recorded in periods of 1 to 7 days.

Period in Days	Average Maximum				Average Minimum			
	1	2	3	7	1	2	3	7
January.....	9.3	17.4	24.6	48.9	0.1	1.4	5.2	21.7
February.....	9.8	18.2	25.3	50.9	0.2	2.8	6.2	25.5
March.....	10.6	19.8	29.0	60.1	0.1	2.2	6.1	26.9
April.....	12.1	23.3	33.6	68.7	0.4	4.6	10.6	35.2
May.....	12.8	25.0	36.5	78.3	0.1	2.4	6.6	32.9
June.....	12.9	25.1	37.0	79.9	0.5	3.6	9.0	37.0
July.....	13.0	25.6	37.9	84.4	2.0	6.6	12.7	47.2
August.....	12.6	24.5	36.0	79.4	0.7	5.1	11.8	41.5
September.....	11.5	22.3	32.5	70.8	0.7	4.3	9.1	34.1
October.....	10.4	20.2	29.4	62.5	0.1	1.6	4.9	23.4
November.....	9.8	19.0	27.2	57.3	0.1	1.8	4.8	22.9
December.....	9.1	17.0	24.0	48.1	0.1	1.8	5.1	21.0

TABLE 18. Average extremes recorded each month in periods of one to seven days.

It is seen that each month of the year has normally at least one day with 9 hours, two days with 17 hours, three days with 24 hours and a week with 48 hours. In the sunniest month, July, there are usually occasions of 1, 2, 3 and 7 days which have respectively 13, 25, 38 and 84 hours of sunshine.

On the other hand July has normally no day with less than 2 hours and no week with less than 47 hours so that the dullest week in summer has approximately the same sunshine as the brightest in winter. In December the dullest week has normally 21 hours.

Table 19 shows that except for December, which has not had more than 9.8 hours in a day, every month has had a day with ten hours or more. May to September inclusive have each had thirteen hours with the highest of 13.4 hours in both June and July.

In all periods shown in the table, December has had the smallest maxima and June the highest. This is one of the few tables in which the yearly summer extremes are not found in July.

Period in days	1	2	3	4	5	6	7
January.....	10.2	19.1	28.4	38.1	47.4	54.2	62.1
February.....	10.6	21.1	31.0	41.0	49.2	58.0	65.0
March.....	11.8	22.6	32.6	42.4	53.1	64.1	74.3
April.....	12.5	24.3	36.3	48.0	59.6	71.0	81.4
May.....	13.3	26.1	38.9	51.1	63.2	75.4	87.4
June.....	13.4	26.8	40.0	53.1	65.7	77.9	90.9
July.....	13.4	26.4	39.1	51.9	64.7	77.3	89.9
August.....	13.0	25.8	38.3	50.8	63.6	76.1	88.1
September.....	13.2	25.2	36.9	47.9	59.6	70.3	82.8
October.....	11.0	21.4	31.9	41.9	52.2	62.0	71.0
November.....	10.4	20.7	29.7	38.6	48.2	55.4	63.6
December.....	9.8	19.0	28.1	35.8	45.0	49.7	56.8
Year.....	13.4	26.8	40.0	53.1	65.7	77.9	90.9

TABLE 19. Greatest amounts of sunshine recorded each month in periods of one to seven days 1927 to 1951.

The lowest weekly maximum is 56.8 hours in December, and all other months have had over 60 hours with over 80 in April to August and the highest of 90.9 hours in June. This total of almost 13 hours daily for a week occurred from 23rd to 29th June, 1938.

In Table 20 we see that the lowest values for each period were recorded in November and the highest in August.

Except for August, each month has had two successive days without sunshine, and except for June, July and August, each month has had four days with less than three hours. November has had five sunless days and March five days with less than an hour.

The lowest total in a week is 1.1 hours in November, which occurred from the 3rd to the 9th, 1931, when one day with 1.1 hours separated one sunless day from a stretch of five others. The 2nd had only 0.1 hour recorded so that the 8 days, 2nd to 9th November, had a total of 1.2 hours. May has had the next dullest week, the 14th to 20th, 1951, having had a total of only 5.4 hours. Both these extremes are rather exceptional, no other week in November having had less than 9.7 hours and the second dullest in May had 18.8 hours.



Period in days	1	2	3	4	5	6	7
January.....	0	0	0.1	1.7	2.7	8.2	12.6
February.....	0	0	0.5	2.5	3.3	4.2	10.5
March.....	0	0	0	0	0.7	9.1	13.6
April.....	0	0	0.9	2.6	8.6	13.9	17.7
May.....	0	0	0	0.2	1.0	3.1	5.4
June.....	0	0	1.5	3.5	5.5	5.5	10.2
July.....	0	0	1.0	4.3	9.0	13.3	18.0
August.....	0	0.1	2.0	7.4	13.2	19.3	23.3
September.....	0	0	0	0.2	3.8	6.3	10.6
October.....	0	0	0.1	1.4	2.6	4.4	4.4
November.....	0	0	0	0	0	1.1	1.1
December.....	0	0	0.3	1.2	4.5	5.6	9.0
Year.....	0	0	0	0	0	1.1	1.1

TABLE 20. Smallest amounts of sunshine recorded each month in periods of one to seven days, 1927 to 1951.

## 10. COMPARISON WITH UNITED STATES RECORDS

In the United States the standard sunshine recorder is of a type which operates through the differential heating of blackened and clear bulbs of an air thermometer. The bulbs are separated by a column of mercury which closes an electric circuit when the instrument is exposed to radiation. The response of this instrument to radiation is different from that of the Campbell Stokes so that the former gives smaller values in the winter and larger in the summer.

In addition it is usual in the United States to add to the duration as recorded by the instrument a "low sun correction" for periods just after sunrise and shortly before sunset when the observers note that the sun was shining but the instrument did not record. The average amount of this correction is about one hour per day but at some stations it averages more than two hours per day in some months.

The question of interconversion from one system to the other to allow of comparison between the United States data and records elsewhere has been studied by C. F. and E. S. Brooks of Harvard University and their conclusions are given in the Journal of Meteorology for August, 1947.

	Average from Campbell-Stokes Recorder		Correction as given by Brooks		Averages for Bermuda as adjusted to U.S.A. procedure		
	Daily	Monthly	Daily	Monthly	Daily	Monthly	Percent'ge of possible
January.....	5.1	157.0	0.2	6.2	5.3	163.2	51
February.....	5.4	153.7	0.5	14.1	5.9	167.8	54
March.....	6.3	194.6	1.2	37.2	7.5	231.8	63
April.....	7.5	226.3	1.3	39.0	8.8	265.3	68
May.....	8.2	254.3	1.7	52.7	9.9	307.0	72
June.....	8.6	258.5	1.6	48.0	10.2	306.5	72
July.....	9.9	305.4	2.1	65.1	12.0	370.5	85
August.....	9.0	278.8	1.3	40.3	10.3	319.1	77
September....	7.9	236.9	1.5	45.0	9.4	281.9	76
October.....	6.3	195.9	0.7	21.7	7.0	217.6	62
November....	5.8	174.0	0.3	9.0	6.1	183.0	58
December....	4.9	152.5	0.1	3.1	5.0	155.6	50
Year.....	7.1	2587.9	1.0	381.4	8.1	2969.3	67

TABLE 21. Average monthly sunshine in Bermuda adjusted to be comparable with American records.

In their paper it is shown that the combined effect of the instrumental differences and low sun correction usually mean that an amount must be added to a Campbell Stokes reading to bring it up to the record which would be obtained under the same conditions using United States' instruments and procedure. Further, this "correction" is greater in the summer than in the winter and greater in the Southern United States than in the northern.

Owing to the latitude of Bermuda the conversion factors given for the Southern States are more applicable. Table 21 gives the conversion values in hours per day as given in Brooks' paper and the average monthly values in Bermuda as adjusted with this factor to give figures which are comparable with United States records.

From November to January inclusive the correction is less than 20 minutes a day but in March to September inclusive, it is over 70 minutes with a maximum of over two hours per day in July. The total correction over a year is 381 hours, more than one hour a day and about 15% of the annual total as measured with the Campbell Stokes.

Meteorological Office,  
Bermuda.  
June, 1952.