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## The Colour of Moonlight

The Editor of the *Meteorological Magazine* has asked me to sum up the interesting correspondence which has resulted from my letter in the November number raising the question why moonlight appears blue.*

Space does not permit me to reproduce all the opinions expressed and to discuss each in turn, so I propose to give my own final impression after carefully studying the whole correspondence and making further observations on my own account. The whole problem may be divided into two separate questions:—

(*a*) What is the physical colour of a landscape illuminated by moonlight?

(*b*) Why is moonlight associated with a blue colour in the minds of most people and in the pictures of most artists?

To the first question there is only one reply: physically the colour of a landscape illuminated by moonlight is the same as it would be if illuminated by sunlight. The only change is one of intensity, sunlight being approximately 400,000 times as bright as moonlight. This applies both to the colour of the sky and to the colour of the ground and objects on it.

The reply to the second question follows directly from this when we take into account the physiological factor of the threshold of colour vision. Whether the sky is overcast or clear the brightness of the sky is always greater than the brightness

*See *Meteorological Magazine,* Vol. 67, 1932, pp. 234, 254, 256, 284; Vol. 68, 1933, pp. 9, 135.

(2722) 32/91 1,050 8/33 M. & S. Gp.303

of the ground and objects on it. The brightness of objects illuminated by the moon (except those very near to the observer) is always below the colour threshold. Therefore no colour can be seen on the surface objects, they can only be distinguished by different intensities of illumination to which no colour term can be applied. On the other hand the brightness of the sky in moonlight often approaches and occasionally exceeds the colour threshold. But the colours of the sky are very limited. Neglecting for the moment the reds associated with sunrise and sunset the colour of the sky is always blue with varying amounts of white. In full daylight the colour of the sky can only change from a deep blue, through a milky blue to white or grey. If therefore any colour at all can be distinguished in moonlight it can only be the blue of the sky. That the intrinsic brightness of the blue sky in moonlight can exceed the colour threshold is quite certain and is testified to in the correspondence by Mr. Bennett's figures and Mr. Bonacina's direct observations. Thus if any colour at all can be seen in a moon-lit landscape it must be blue and only blue.

Returning for a moment to the reds of sunrise and sunset: these must be present to the same extent in moonlight, and we all know that the moon itself on rising and setting is often a deep red or golden yellow, and the only reason why we do not see these colours in the sky at moon-rise and moon-set is because the scattered red light is too weak to rise above the colour threshold. In any case the possibility of some red light in the sky just at moon-rise and moon-set does not detract from the above argument that in bright moonlight blue is the only colour which can be discerned by the eye.

Now let us consider the artist who wishes to paint a moonlight scene. His high lights are all in the sky and these must be some shade of blue. Now he wishes to indicate the form of the landscape, but all this has no colour except where it directly reflects the colour of the sky. He must therefore paint his whole picture in gradations of blue, ranging from the bright blue of the sky to the blacks of his deepest shadows. The reverse is equally true: when we see a picture ranging from blue to black we at once associate it with moonlight. Thus we have the explanation of the picture which I saw in Cockspur Street and which started the whole correspondence—a photograph of a ship, obviously taken in daylight, but which appeared to be taken in moonlight, because printed on blue photographic paper.

G. C. SIMPSON.

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## Resultant Wind Direction in London: its periodicities and its effect on rainfall

By C. E. P. BROOKS, D.Sc., and THERESA M. HUNT.

In May last we contributed to the Royal Meteorological Society a statistical paper on the variations of wind direction over the British Isles, which will be published in the *Quarterly Journal* for October, 1933. This paper gives the resultant direction of the wind for winter, summer and the year, over as long a period as possible, for London, Edinburgh and Dublin. The resultants are described as " direction-frequency vectors," in other words, they are obtained by giving equal weight to each observation of wind direction, without taking into account the velocity. The data obtained include a long complete series of resultants for London from 1787 to 1930, and this series seemed to offer an excellent basis for an investigation of the periodicity of wind direction in London.

In the paper presented to the Society the data are given in the form of resultant direction in degrees and " constancy," the latter being expressed as a percentage. For the investigation of periodicity, however, it was more convenient to utilise the north and east components which were already available in the working sheets. These figures were first explored by means of the " difference periodogram,"* which affords a rapid survey of any long series of observations, the finer details being examined more closely after the approximate lengths of the major periodicities had been found by the rougher method. The preliminary analysis suggested the existence of periodicities of approximately 3, 4½, 5, 6½ and 11 years, but of these only the 3-year cycle appeared with any definiteness in both the north and east components, with a length between 2·95 and 3·05 years. The 5-year cycle appeared clearly in the north, but not in the east component. Periodicities longer than 15 years were looked for by the usual direct methods. The investigation was confined almost entirely to the figures for the year, but the possible existence of a 2·5-year component of the 5-year cycle was verified by reference to the data for winter and summer.

Subsequent examination was carried out by the ordinary method of harmonic analysis. The annual and semi-annual cycles were also calculated for comparison. The results are shown in the following table as the constants a and $\phi$ (amplitude and phase) of the series $W = a \sin (t + \phi)$.

| *Period.* | *N. Component.* | | *E. Component.* | |
|---|---|---|---|---|
| Years. | Amp. °/₀ | Phase at Jan. 1, 1931. | Amp. °/₀ | Phase at Jan. 1. 1931. |
| 0·5 | 5·0 | 248° | 6·0 | 226° |
| 1·0 | 9·1 | 308 | 4·4 | 339 |
| 3·0 | 4·3 | 27 | 6·6 | 117 |
| 4·5 | 2·3 | 240 | 3·0 | 125 |
| 5·1 | 6·1 | 22 | 0·8 | 90 |
| 6·5 | 2·4 | 256 | 1·7 | 78 |
| 11·2 | 1·3 | 61 | 1·3 | 69 |
| 34 | 3·3 | 217 | 1·8 | 7 |
| 51 | 2·8 | 202 | 4·5 | 309 |

The standard deviations of the annual wind resultants are

*London, Proc. R. Soc., 105A, 1924, p.346.

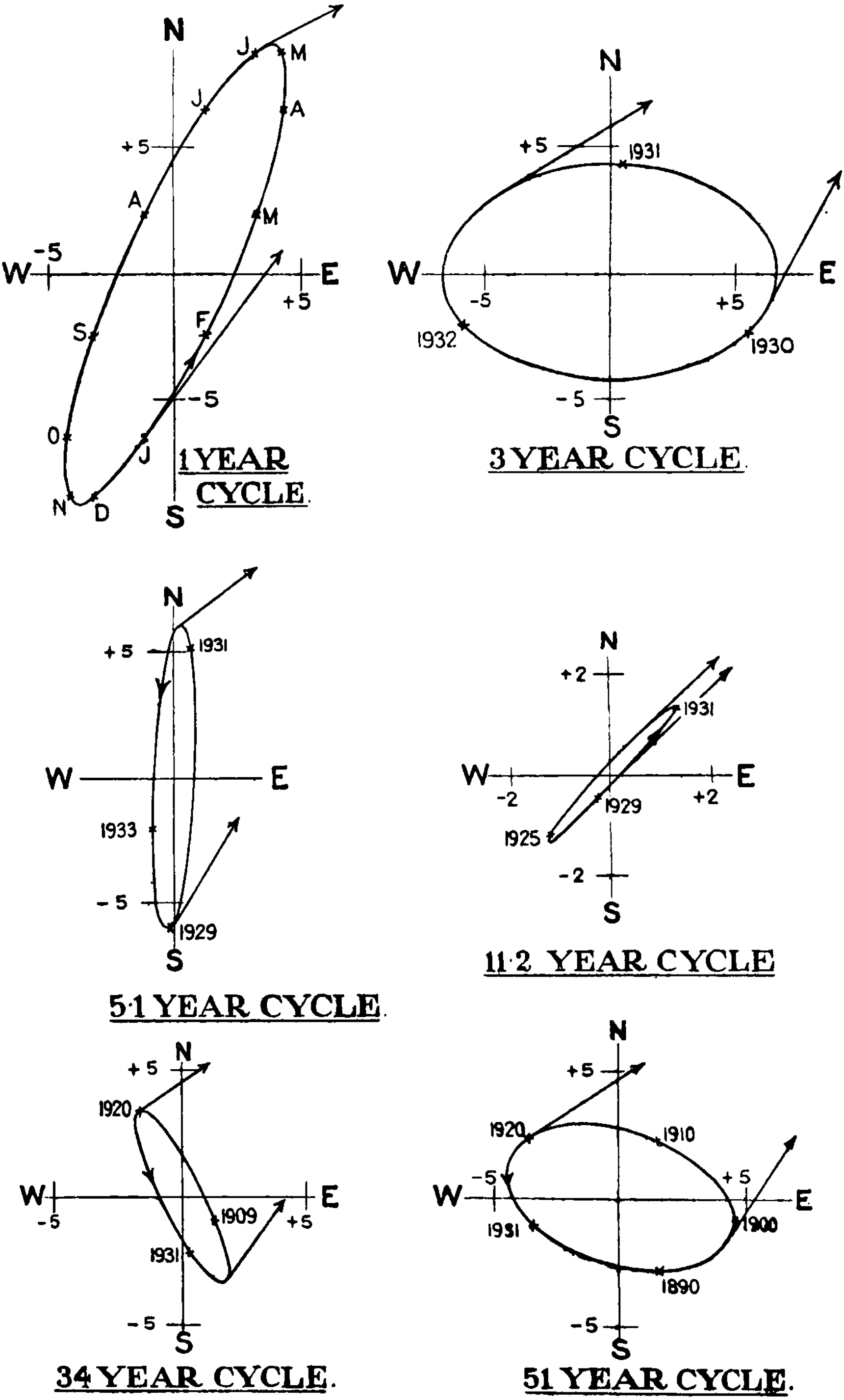



Fig. 1.—Wind Periodicities.

5·7 per cent. for both the north and east components.* The average resultants of the whole period are: N component 15·2 per cent; E component 14·9 per cent, in other words the average wind direction in London is almost exactly from SW.

The annual periodicity, and those of 3·0, 5·1, 11·2, 34 and 51 years, are shown graphically in figure 1, which may require some explanation. The intersection of the areas represents the average wind direction on which the periodicities are superposed. Each figure is divided by these axes into four quadrants; a point in the upper right-hand quadrant represents the superposition of a wind from NE. on to the average wind, in the upper left-hand quadrant a wind from NW., and so on. Thus in the figure for the 3-year cycle, if we suppose the cycle to begin in 1930, at the middle of that year, represented by the small cross, a wind from ESE. is superposed on the normal SW. wind. As the year passes, the superposed wind becomes first easterly and then north of east. By the middle of 1931 the superposed wind is northerly, early in 1932 it becomes westerly, and at the end of 1932 it is southerly. Since, however, this 3-year cycle is superposed on a fairly steady SW. wind, the average variation of the actual wind resultant during the cycle is only from SSW. to WSW., as is shown by the two short arrows tangent to the ellipse. Even this amount of variation, however, is quite considerable. Similar arrows are shown on the remaining ellipses.

The diagrams present several points of interest. The first is that, contrary to the usual run of meteorological phenomena, the annual periodicity is little more marked than the longer cycles. The second point is the varying nature of the ellipses, that for the 3-year cycle approaching a circle while the 5·1- and 11·2-year cycles are almost linear. The third point is that the direction in which the resultant follows the ellipse is counterclockwise in all six cases. We will return to this point later.

The 1-year cycle forms a long, narrow ellipse, the winds being most westerly and least constant in early summer, least westerly and most constant in winter. The constancy is shown by the length of arrows from the point where they touch the curve to the point at which they would meet if produced. It should be remarked, however, that as the half-yearly term is almost as large as the annual term, the actual annual variation is much more complicated than that shown, which is included merely for comparison. The 3-year cycle has the largest variation of the east-west component of any of the periodicities affecting the winds of London—larger even than the annual variation—but the north-south oscillation is less marked. It will be

*Owing to the difficulty introduced by the great change of average direction about 1810, the standard deviation was calculated indirectly from the change between one year and the next.

remembered that a 3-year cycle was for a time very prominent in the rainfall of the British Isles.

The 5·1-year cycle was discovered by Mr. E. Baxendell* in the frequency of northerly and north-easterly winds at Southport and Greenwich, and also in many other meteorological records of the British Isles. It is also significant that there is a periodicity of five years in the occurrence of winters of severe frost in London. From the results obtained here, which otherwise closely confirm those of Mr. Baxendell, it would appear that the variation appears mainly in the frequency of northerly and southerly winds.

The 11·2-year cycle is inserted for its general interest, although it is really insignificant (the scale of this ellipse is double that of the others). It appears definitely as a variation in the constancy of the SW. wind, without appreciable change of the average direction. It should be noted that the last sunspot maximum occurred in 1928, so that there is a lag of three years between the sunspot maximum and the least steadiness of south-west winds.

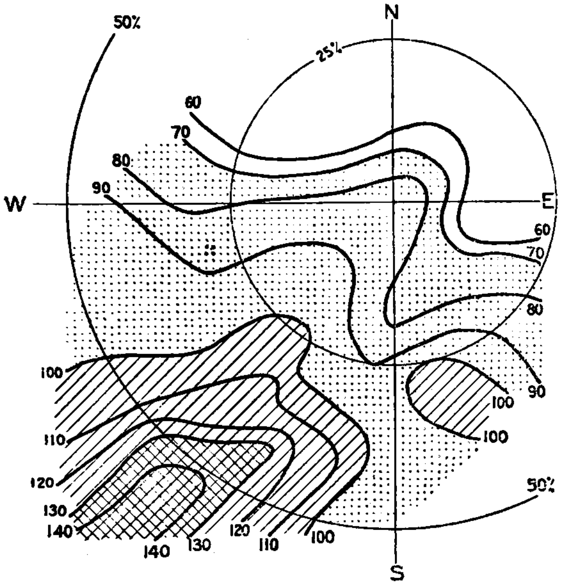
The 34-year periodicity presumably represents the Brückner cycle, but the exact length was rather indeterminate. More definite is the 51-year cycle, which is also clearly shown in the rainfall of England. The last rainfall maximum occurred in 1926, when the wind was most westerly; the dry periods correspond with the greatest easterly component, as would be expected.

We have already referred to the curious feature that the direction of oscillation of the resultants is in all these cases anti-clockwise, as shown by the arrows on the ellipses. We cannot see any obvious explanation of this, but we may perhaps venture a suggestion. The annual cycle can be regarded as a result of the annual variation of the sun's radiation in the neighbourhood of the British Isles, working through the distribution of land and water. If the longer cycles are also of solar origin (this is known to be true of the 11·2-year cycle and strongly suspected for the Brückner cycle) it would be reasonable to expect that they should take the same general course. Against this is the point that the major axes of the ellipses are all inclined at different angles to the horizontal, and at present we do not think it would be profitable to pursue the matter further.

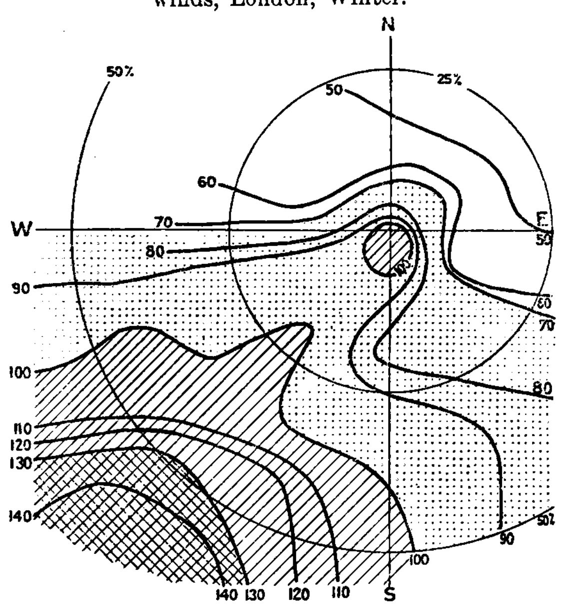
The wind resultants were also used to examine the relation between the general direction of the wind during a season, and the rainfall during the same season. The results are shown in figures 2 and 3. Here resultant wind direction and " constancy " are shown by reference to two axes at right angles, while the two circles represent constancy of 25 and 50 per cent. Thus a point on the left-hand axis labelled " W " represents a

*London, *Q.J.R. Meteor. Soc.*, 51, 1925, p.371.

resultant wind from west. The results were worked out separately for the rainfall of London (1797-1930) and for "England and Wales" (1727-45, 1747, 1787-1930)*, but in each case the winds refer to London. Rainfall is given as a percentage of the normal for the period 1881 to 1915. The winds for the period 1787 to 1840 have been corrected to make them comparable with the observations at the Royal Observatory; the data for 1727-45 were obtained at Richmond and those for 1747 at St. John's Gate, and have not been corrected.



Rainfall (percentage of normal) and resultant winds, London, Winter.



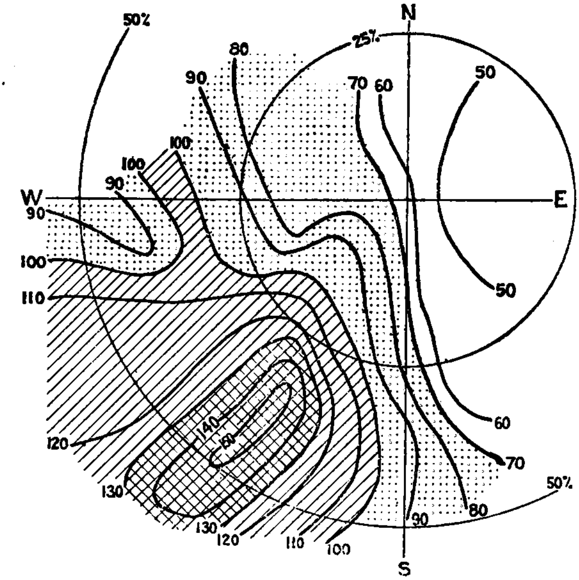
Rainfall (percentage of normal) England and Wales and resultant winds, London, Winter.

Fig. 2.

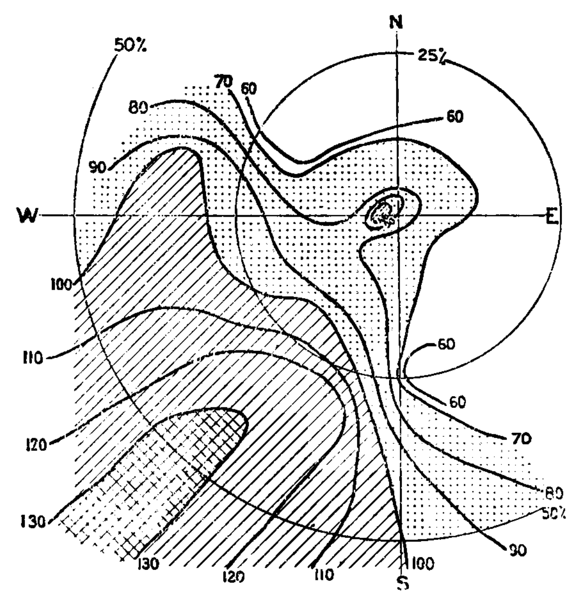
Figure 2 shows the results for winter (December, January, February). The upper half shows the diagram for London. The figures for individual seasons required a good deal of smoothing and the minor details may not represent real phenomena, but the general result is clear, and is in accord with experience. The heaviest rains come when the winds blow steadily from south-west (actually a little south of

*: *British Rainfall*, 1931, pp. 299-306.

south-west). The seasonal rainfall is least when the prevailing wind is from east to south-east or from a little west of north; with north-easterly winds the deficiency is somewhat less pronounced. There is a small area of rain above normal with winds a little south of east which, from the plotting of the individual values, appears to be a real phenomenon. The heavily shaded area represents an expectation of rainfall above 130 per cent. of normal, the lightly shaded from 130 to 100, the stippled area from 100 to 70, and the white area below 70 per cent. The lower half of the diagram shows the corresponding results when the winds of London are compared with the average rainfall of England and Wales. This is on the whole very similar to the London diagram, including even the relative raininess of winds from north-east compared with winds from east and from west of north. An additional feature of interest however is the area of rainfall above normal at the intersection of the axes, *i.e.*, in




Rainfall (percentage of normal) and resultant winds, London, Summer.




Rainfall (percentage of normal) England and Wales, and resultant winds, London, Summer.

Fig. 3.

seasons with no predominant wind. These presumably represent seasons in which series of depressions passed directly across England, giving highly variable winds.

Figure 3 gives similar results for summer (June, July, August). London rainfall is again shown above. This differs from the diagram for winter in several interesting respects. While a wind from south of south-west is still the greatest rain-bringer, the heaviest seasonal totals (exceeding 150 per cent.) occur when the constancy is less than 50 per cent. With steadier south-westerly winds the rainfall again decreases. It may be that thunderstorms, which bring a considerable part of London's summer rainfall, become less frequent when the south-west winds are unusually persistent. A similar decrease is shown for westerly winds of unusual steadiness. The secondary maximum of rainfall with north-easterly winds has disappeared, and the driest conditions are given as would be expected by winds from due east. The diagram for England and Wales as a whole differs in several respects. The range of values is considerably less, and the closed maximum with south-west winds of moderate constancy has disappeared—perhaps because the part played by thunderstorm rains relative to orographic rains is less important for the country as a whole than for London alone. The smallest totals occur with winds from a little west of north and east of south, and the secondary maximum with very variable winds appears as in the winter.

The narrowness of the area of heaviest rainfall is a remarkable feature in three of the four diagrams. The most favourable direction of the resultant for heavy rain is: London, winter, 218°; London, summer, 213°; England and Wales, summer, 220°. This holds over a range of constancy of 20 per cent. or more, yet a change in the resultant wind direction by only 10 degrees may change the expectancy of rainfall by 10 per cent. or more. It is an interesting problem why a season in which the prevailing wind blows from a little south of south-west should normally have so much more rain than a season in which the prevailing wind blows from a little west of south-west or a little west of south.

The diagrams may be described as a novel form of rainfall wind rose. They may be compared with a similar diagram for an equatorial island—Ocean Island—which was published in the *Meteorological Magazine* for March, 1926, p. 42. The results for England are not so sensational as for Ocean Island, but they do serve to illustrate our climate from a somewhat unusual angle.

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Mr. A. Westley of Crieff House, Blisworth, Northamptonshire, has 27 copies of *British Rainfall* from 1894 to 1920 in excellent condition which he would like to sell at a reasonable price.

# Correspondence

To the Editor, *The Meteorological Magazine.*

## Cyclone in the Fiji, Tonga, and Cook Island Groups

On the early morning of January 5th, 1933, the Union Steamship Company's R.M.S. *Maunganui*, Captain A. T. Toten, encountered the central portion of a tropical cyclone. During the period from December 30th to January 5th, pressure was unusually low and the weather very disturbed over a wide area in the tropics extending from west of Fiji to east of the Cook Islands. On January 1st a depression, which appeared from the information available to be only a shallow one, was situated west of Rarotonga (Cook Islands). This depression evidently passed south of Rarotonga on the 2nd. In the meantime a deep cyclone had appeared about 200 miles north of Suva on the 1st. This cyclone moved fairly steadily in an east-south-east direction to the position where the *Maunganui* passed through it. Both storms appear to have developed along the same cold front and moved in a direction almost parallel to it.

The following is taken from an account furnished by Mr. J. E. Brompton, 3rd Officer of the *Maunganui*. The vessel was on a voyage from San Francisco to Wellington via Papeete (Tahiti) and Rarotonga :—

*Jan. 1st.* Left Papeete at 17h. Weather fine and clear, wind light northerly, bar. 1009mb.

*Jan. 2nd.* Northerly wind freshened and sky became cloudy. At noon it was overcast and gloomy and a moderate north-west swell was setting in. Bar. 1007·6mb. At 13h. 30m. a drizzle commenced and continued to 15h. At 18h. the wind freshened and towards midnight there were heavy squalls (up to force 9-10) and rain. Bar. at 24h. 1004·2mb.

*Jan. 3rd.* At 8h., wind N. 6, reaching force 9 in squalls, weather *or*, bar. 1000·5mb., visibility poor to moderate. Rarotonga sighted at 9h. The north-westerly swell increased as the Island was approached, being recorded as WNW 6 on the international scale. The vessel was unable to take up her usual anchorage. At noon, wind had backed to WNW 4-5, bar. 1002·6mb., weather *orq*. These conditions continued till midnight, when bar. read 1001·9mb.

*Jan. 4th.* At 1h., wind fell light (NW. 2) and rain ceased. At 1h. 30m. wind came from SW., force 5-6, and backed rapidly to SE. by 2h. and moderated. At 4h., bar. 1003·8mb. north-west swell moderated rapidly and vessel stood in, anchoring at 5h. 43m. At 8h., bar. 1006·2mb., weather overcast but fine, wind SE. 3. The weather deteriorated during the afternoon, rain setting in. Rarotonga was left at 17h. 20m., the course being 221°. At 18h., wind ENE. and backing during heavy rain. At 19h. 40m., wind NNE. 4. At 20h., wind N. 4-5, bar. 1003·3mb., weather overcast with heavy rain, which ceased at 20h. 15m. Thunder and vivid lightning observed from 20h. to 21h. Heavy rain again from 21h. 30m. to 22h. 15m., when sky had an ugly, threatening appearance. At 23h., wind NNE. 7-8, sea rising rapidly. At 23h. 55m., wind NNW., force 12, with a mountainous sea and vessel hove to.

*Jan. 5th.* At 0h. 30m., bar. 969mb., wind showing signs of moderating. At 0h. 50m., bar. 972 mb., wind WSW. 7, sky overhead through the spume was seen to be clear with stars shining. The wind continued to back and barometer to rise as follows:—

| | | | |
|---|---|---|---|
| 1h. 15m. | WSW. | 11-12, | bar. 976mb. |
| 1h. 30m. | SW. | 12, | ,, 980 ,, |
| 2h. 00m. | SSW. | 12, | ,, 985 ,, |

This was the height of the storm, the wind of terrific force with a mountainous confused sea. The vessel's boats were lifted out of their keel chocks (4 inches) and several stove in. The weather accident boat, carried outboard in strops, was lifted and only saved by the davits from capsizing on deck. A notice *rè* propellers outside the poop railings was torn from its bolts and disappeared. Several ventilators were lifted from their coamings, and two plugs (wooden) to ventilator shafts not in use were blown out. A heavy sea was shipped on the port quarter and the side rails were torn away. At 2h. 20m., bar. 992mb., wind SSW 10. At 2h. 45m. a noticeable improvement had taken place, bar. 993mb., wind force 7-8, sea heavy and confused with an occasional very heavy swell. At 3h. 20m., wind SSW. 7, bar. 995·3mb., temperature 75·3°, heavy but fast moderating sea, sky clear. At 3h. 36m. the weather had so far improved that an easy full speed was possible, and the vessel resumed her course. At 4h., wind SSE. 7, bar. 996mb., sea south-south-east 5, swell, south 7, sky clear, except for low bank of black cloud to southward. At 8h., wind SE. 5, bar. 1004·2mb., sea south by east 4, confused moderate swell, weather overcast but fine.

From this account and the rate of travel of the storm, it would appear that the severe central portion could not have been more than 30 to 70 miles in diameter. The times given are ship's times, but the dates are New Zealand dates.

E. KIDSON.

*Meteorological Office, Wellington, New Zealand. May 4th,* 1933.

[This account shows several features of interest: the winds from NNW., force 12, on the eastern side of the depression and from SSW., force 12, on the western side, separated by a period of lighter winds from WSW., during which the sky cleared overhead. Evidently the ship passed slightly to the north of the storm centre. Although barometer readings during the approach of the cyclone are not given, the fall of the barometer was evidently almost as rapid as the subsequent rise.—ED. *M.M.*]

## Peculiar Temperature Phenomenon

On passing along the 4 mile flat road through the open Burgh Marsh at 9.30 p.m. B.S.T. on the evening of July 18th, the writer passed through alternate hot and cold bands of air, each about 50 yards wide, the change from one band to the next being very sudden.

Although a thick ground mist was to be seen on either side of the road within 100 yards, there was no mist along the road itself, while the only ditches in the vicinity run alongside the road, and not across the line of it.

This would tend to dispel the suggestion that the sensation of cold was caused by suddenly entering a zone of air in which the humidity was increased by the presence of a ditch, and I should be interested to hear the opinions of readers as to the cause.

R. H. JENKINS.

*Town Hall, Skegness, Lincolnshire. July 19th,* 1933.

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## Spells of Sunshine

The letters of Mr. Dunbar and Mr. Bilham in the April and May numbers of the *Meteorological Magazine* have prompted me to examine the Lympne sunshine records for the 12 years, 1921 to 1932, with a view to determining the frequency of sunny or dull spells which satisfy certain specified conditions. May I suggest that instead of making the period of a sunny spell 30 consecutive days or more, as has been proposed, we adopt 29 days as the limit? This is the length of period laid down in the definitions of rain spells and partial droughts, and it would, I feel, be an advantage to use the same period in classifying spells of sunshine. The period of 15 days suggested for bright spells and dull spells is already equal to that used in determining droughts and wet spells.

Assuming then that a sunny spell is " a period of at least 29 consecutive days on all of which there is recordable sunshine," Lympne had 24 sunny spells in the 12 years 1921-32. These sunny spells were practically all confined to the summer months, but one commenced as early in the year as February 21st (1924) and two others began on March 6th (1921) and March 7th (1928). The spells frequently extended to the latter half of September, but only one continued into October. This unusually late sunny spell lasted for 36 days from September 20th to October 25th, 1921. The duration of the spells varied considerably. Five just satisfied the conditions, lasting exactly 29 days; five lasted for more than 50 days and two for more than 100 days. These two remarkable spells extended from May 8th to August 20th, 1921, and from May 24th to September 27th, 1928. Over these periods of 105 and 127 days respectively the recorded sunshine reached the high average of eight and a half hours daily. The mean duration of all the 24 spells was 45 days.

Mr. Bilham suggests that a bright spell might be a period of 15 days each with " one-fourth of the possible mean daily duration." If this criterion is applied to the Lympne records it is found that 16 such spells occurred in the past 12 years, varying in length from 15 to 26 days. It seemed worth while to determine how many cases occur if criteria other than " one-fourth " are adopted, and Table I shows the results of taking one-tenth, one-fifth, one-quarter, one-third and one-half of the possible mean daily duration as the criteria.

TABLE I.—*Periods of* 15 *days or more, each day having a proportion of the possible mean daily duration of sunshine equal to or exceeding that shown in the first line of the table.*

| | 1/10 | 1/5 | 1/4 | 1/3 | 1/2 |
|---|---|---|---|---|---|
| Number in 12 years ... ... | 31 | 19 | 16 | 10 | 1 |
| Length of longest spell (days) ... | 54 | 27 | 26 | 23 | 16 |
| Mean length of spells (days) ... | 23 | 24 | 19 | 17 | 16 |

Of the 16 sunny spells which satisfy the proposed condition, the most in any one year was three in 1921. None occurred in 1922 and 1926. The table appears to indicate that Mr. Bilham's suggestion that " one-fourth of the possible mean daily duration " should be the criterion of a sunny spell is admirably chosen.

Examination of the records suggests that " a period of at least 15 days, none of which has one-fourth of the possible mean daily duration " is too limiting as a definition of a dull spell. Only one period fell within these limits in the 12 years' observations at Lympne. Table II shows the results of using proportions of the possible mean daily duration similar to those utilized in the determination of bright spells.

The results indicate that, if a period of 15 days or more is to be adhered to, it will be necessary to make the limiting condition " one-half of the possible mean daily duration." This introduces an anomaly which at first may appear serious since it would be possible, in theory, for a sunny spell to be also a dull spell. In practice this has not happened in 12 years and the chance of it occurring, even in 100 years, is sufficiently remote to be ignored.

The proposed definition of a sunless spell as a period of 15, or even 10, successive days with no recordable sunshine seems to be putting the limit unduly high. A well-exposed station, free from the effects of town smoke and not subject to frequent

TABLE II.—*Periods of 15 days or more, no day having a proportion of the possible mean daily duration of sunshine exceeding that shown in the first line of the table.*

| | 1/10 | 1/5 | 1/4 | 1/3 | 1/2 |
|---|---|---|---|---|---|
| Number in 12 years ... ... | 0 | 1 | 1 | 2 | 13 |
| Length of longest spell (days) ... | — | 16 | 16 | 17 | 29 |
| Mean length of spells (days) ... | — | 16 | 16 | 17 | 19 |

fogs would rarely record such a spell. Not a single instance occurred at Lympne between 1921 and 1932. Mr. Bilham notes one such spell at Kew in 1931, but I think he would admit that Kew is affected by London's smoke and by the river fogs. The longest sunless spell at Lympne was 8 days from November 27th to December 4th, 1927; one sunless period lasted for 7 days and three others for 6 days each. A week without sunshine has an unpleasant effect upon most of us, and I suggest that it is sufficiently noteworthy to be classified even though this would be a departure from the original plan in fixing the length of a spell.

Lympne is 350 feet above mean sea level, two miles from the coast and remote from factories and other sources of smoke production. It is, therefore, favourably situated for recording abundant sunshine; but this could be urged in regard to a majority of health resorts. One might then anticipate that, except in the vicinity of towns or in areas subject to excessive cloudiness, sunny and bright spells will outnumber dull and sunless spells. Having these facts in mind the investigation leads to the suggestion that the following definitions are likely to serve best as a means of classifying sunshine records:—

Sunny spell.—At least 29 consecutive days each with recordable sunshine.

Bright spell.—At least 15 consecutive days each with 25 per cent or more of the possible mean daily duration.

Dull spell.—At least 15 consecutive days none of which had more than 50 per cent of the possible mean daily duration.

Sunless spell.—At least 7 consecutive days with no recordable sunshine.

H. E. CARTER.

*Lympne Air Port, Hythe, Kent, June 16th,* 1933.

## Mirage

The fine days of July 2nd, 3rd, and 4th, 1933, produced some extraordinary mirage effects as viewed over the Irish Sea from Holyhead at sunset.

Usually in exceptional visibility the Isle of Man, situated over 50 miles from Holyhead, appears to the observer as two detached mounds. During the three days in question the whole coastline, stretching through some 20°, was apparent, the undulations, probably much distorted, being very clear. Through binoculars one gained the impression of an island with a very indented coastline especially on its northern side. The phenomenon was observed closely on the 4th from 21h. 30m. B.S.T. and at 22h. 15m. inverted images began to form on the tops of the undulations, the whole island being in a state of continuous change. At times the inverted images were detached thus giving the idea of isolated rocks in the sea on the northern side of the Island.

At 22h. 15m. when the phenomenon was most marked the screen temperature was 59°; the relative humidity was 88 per cent., a trace of mixed cloud was present and the surface wind was light northerly. The observer was approximately 40 feet above Mean Sea Level.

H. L. PACE.

*Salt Island, Holyhead. July 6th,* 1933.

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## Luminous Clouds

There was an occasion of luminous cloud observed at Holyhead at 4h. G.M.T. on June 19th, 1933, which seems to be worthy of note. There were 3/10ths of strato-cumulus present, and in a north-westerly direction a trace of cirrus cloud in the shape of a tuft above a layer of strato-cumulus. The cirrus was a bright white and was at an elevation of some 5° above the horizon. The night was "light," with good visibility and there was an occasional flash of lightning to the east.

On the previous day the weather had been squally with slight rain in the forenoon, followed by heavy rain showers in the afternoon, with the wind reaching gale force in squalls from a westerly point.

H. L. PACE.

*Salt Island, Holyhead. July 6th,* 1933.

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At 0h. 45m. B.S.T. on July 3rd, a small, luminous and somewhat lenticular patch of what was classed by the observer to be cirro-cumulus, was observed at an elevation of 5° approximately to the north-north-west. The only other type of cloud present was a layer of strato-cumulus, lying so low on the northern horizon, as to make the latter invisible. The total amount of cloud present covered rather less than one-twentieth of the sky, which was fairly starry, it being near moonset. The cirro-cumulus had a phosphorescent-like luminosity and was shadowed in parts.

The sky in its immediate vicinity had a whitish-blue appearance, which was the more arresting since it was placed between the faint haze afterglow of the sunset above the strato-cumulus to the north and the remainder of the appreciably darker sky. The cloud patch was observed for about half an hour in all—the amount and elevation appearing very gradually to be increasing and its luminosity was becoming more marked.

At approximately the same time on the 5th, luminous clouds of the same nature were observed in very similar circumstances as in the above, except that the cloud amount was appreciably less, and had a lower elevation. The weather for the past few days had been fine and quiet with exceptional visibility at times.

W. I. JONES.

*Salt Island, Holyhead. July 6th*, 1933.

## NOTES AND QUERIES

### Hailstorm in Derbyshire

According to a letter from Mr. L. Ramsbottom, the Royal Agricultural Show at Derby enjoyed fine but hot weather throughout its five days, except for one brief interval on Friday, July 7th, when a thunderstorm of unusual severity broke over the ground at 2 p.m. The skies darkened, and a few minutes later large hailstones and pieces of ice fell for ten minutes. Very quickly the ground was white all over, and many hailstones were seen as large as gooseberries. Eggs displayed in baskets were broken by the hail. A quarter of an hour after the storm had ceased visitors were picking up the pieces of ice, still the size of marbles, from the ground, and finding in them, cool refreshment under the hot conditions prevailing.

[From descriptions in the *Derbyshire Times*, also sent by Mr. Ramsbottom, the same storm was experienced in the Belper district, eight miles from Derby, shortly after 2 p.m. Many windows and greenhouses were shattered by hail and four cows were killed by lightning. Three of the cows were standing three or four yards from a large ash tree, which was struck. The tree is surrounded by barbed wire, and the bark was stripped to the level of the wire, below which it was intact. Between 30 and 40 wooden stakes supporting the wire round the field were all split, and bark was stripped from trees and bushes touching the wire. The hailstones were the size of marbles. During the storm a hole appeared in the road in Belper Lane; for several feet round the road was forced up into little mounds or waves. The cause is not clear.

At Chesterfield, 24 miles from Derby, the storm, which began just before 3 p.m., was accompanied by a small whirlwind 20 or 30 feet high, which uprooted small trees and carried newly-mown-hay hundreds of yards; it also carried large quantities of grit and sand. Tiles and slates were dislodged from roofs and part of a building in course of erection was blown down, but there were no personal injuries.—Ed., *M.M.*]

## High Pilot-Balloon Ascents at Shoeburyness

Mr. C. E. Britton's note in the *Meteorological Magazine* for July on two exceptionally high pilot-balloon ascents which were made at Shoeburyness on June 15th, seems to point to the existence of a remarkable ascending current on the morning of that day. The balloons used weighed 750 grammes. Little is known about the rate of ascent of balloons of this size in still air, nevertheless, certain conclusions, which seem to be of interest, can be reached. The formula used in this country for the rate of ascent V of balloons is as follows :—

$$V = q \frac{L^{\frac{1}{2}}}{(W + L)^{\frac{1}{3}}}$$

where L is the free lift and W the weight of the balloon in grammes. This formula is based on the assumption that the air resistance varies directly as the cross-sectional area of the balloon and as the square of its velocity through the air. It is known that the formula does not hold rigorously for balloons of widely different sizes, and this is allowed for by assigning a different value to the constant q for large pilot balloons from that used for the smaller sizes. The value of q is best determined by measurement of the rate of ascent of the different balloons. There is abundant evidence that a value of 276 gives the rising velocity (in feet per minute) of the normal pilot balloons weighing 20-30 grammes satisfactorily, while the value 310 is suitable for the large pilot balloons used for certain purposes which weigh 80 grammes. It is a long extrapolation from these weights to the 750 grammes balloons used at Shoeburyness, but the value of q calculated from the rate of ascent of the balloon sent up in the evening of June 15th, works out at 358, a figure which seems to the writer not unreasonable for a balloon of this size. If this value be accepted, the similar balloon liberated in the morning, which had a larger free lift, should have risen 910 feet per minute, whereas actually the rate of ascent for the first 10 minutes, as determined by two theodolites, was 1,260 feet per minute, an excess of 350 feet per minute or almost 6 feet per second. A rising current of this magnitude extending for a height of nearly 2½ miles must be almost unique among upper air observations.

It is understood that further ascents of the same nature are planned at Shoeburyness, and it will be of interest if such are successfully accomplished to have further information regarding the value of q which is appropriate to these balloons.

J. S. DINES.

## The Supposed Periodicity in the Size of Waves

There is a well-known superstition that every seventh wave is larger than the others. I happened to be on the beach on the south coast at high tide on a roughish day, April 12th last, and it occurred to me to test this. After each wave I accordingly wrote down an estimate of its intensity, based on the height of the crest, the noise of impact on the shingle, and the distance which it ran up the shelving beach. Altogether 152 waves were estimated in this way, on a scale ranging from 1—the smallest wave which could be distinguished—to 10, the largest wave seen before the count was begun. The estimates actually written down ranged from 1 to 8.

A subsequent examination of the figures showed a certain rhythm, but the periodicity was definitely not seven. The correlation coefficients between each wave, and the first, second . . . tenth subsequent waves were as follows :—

| 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th |
|---|---|---|---|---|---|---|---|---|---|
| +·26 | —·11 | —·02 | +·07 | +·06 | —·05 | —·10 | —·07 | —·10 | —·22 |

There are thus indications of a periodicity of 4 to 5, but the most marked feature was a variation of longer period. The length of the latter varied, however, the intervals being 17, 20, 16, 21, 15, 13, 15, 19. Probably some of the smallest waves were not independent. On this particular occasion, however, there was certainly no support for the popular belief.

C. E. P. BROOKS.

## Meteorological Service in French Equatorial Africa

An article in the " Dépêche Coloniale " for March 22nd-23rd gives an account of the reorganisation of the meteorological service in French Equatorial Africa, to assist the protection of the air route France-Congo-Madagascar. The service is under the direction of an engineer-meteorologist, and its headquarters will be at Bangui, the main aeronautical centre. A number of observing stations are being established, several with pilot-balloon equipment and wireless equipment for reporting daily. In addition to the testing of instruments and the checking and publication of the observations, researches are being undertaken in seismology, terrestrial magnetism and oceanography. First order stations have already been established at Bangui, Fort Lami, Fort Archambault, Impfondo, Brazzaville and Pointe-Noire, and 13 stations of the second order are in operation.

# The Weather of July, 1933

Pressure was above normal over most of Europe (except the extreme north) over the north coast of Africa, the southern North Atlantic including the Azores and Bermudas, Newfoundland, most of eastern Canada, Mexico and California, the greatest excesses being 4·1mb. at Prague and 5·1mb. at 30° N. 10° E. Pressure was below normal over northern Scandinavia, the extreme north of Russia, Spitsbergen, Iceland, Greenland, western Canada and most of the United States, the greatest deficit being 6·6mb. at Spitsbergen. Temperature was generally above normal in western Europe and Spitsbergen, the absolute maximum of 99·3°F. in Uppsala on the 9th was a record for Sweden since at least 1859. Rainfall was below normal in central Europe and Spitsbergen but in Sweden twice the normal in western Norrland and in western Gothaland, 50 per cent above normal in eastern Svealand and slightly below normal elsewhere.

The weather of the British Isles during July was generally warm and sunny, the mean temperature for the month being as much as 5·6°F. above normal at Kew, 4·3°F. at Aberdeen and 2·4°F. at Valentia, while there was an excess of sunshine except on the western coasts and a general deficiency of rain except in Scotland, where the precipitation was excessive locally, and in western Ireland. The month opened with dry sunny warm weather generally. Temperature rose frequently above 80°F., 88°F. was registered at York on the 3rd and the maximum of 85°F. at Eskdalemuir on the 5th was the highest recorded there since records began in 1910. The 2nd to 5th were very sunny days over the country generally, 16·5hrs. of bright sunshine were recorded at Inchkeith and 16·3hrs. at Berwick-on-Tweed on the 3rd. On the 6th a depression was moving northwards on our Atlantic seaboard and thunderstorms occurred over the country generally on the 7th and more locally on the 8th. Minimum temperatures were high at this time, 68°F. being recorded in the screen at Bognor and 66°F. at Southsea, Portsmouth, Worthing, Hastings and Aberystwyth on the 7th. From the 8th until the 15th pressure was low to the north and secondaries frequently passed across the country giving cooler and thundery weather with thunderstorms and heavy rain locally but sunny intervals, 1·68in. fell at Llyn Fawr (Glamorgan) on the 9th and 1·12in. at Edinburgh on the 13th, and at Bath and Frome on the 15th, and maximum temperatures ranged chiefly between 60°F. and 70°F. On the 16th, a wedge of high pressure was approaching from the Atlantic, and sunny anticyclonic conditions prevailed over the whole country for the next few days. Much mist and fog occurred round the southern coasts between the 17th and 19th. From the 19th to 30th pressure was low to the north-west, giving unsettled weather with some rain but many sunny intervals in Scotland and Ireland, while fine warm sunny weather prevailed in England until the 27th, when there was a change to cloudy, cooler weather. From the 18th to 27th high temperatures occurred in England, reaching a peak on the 27th when 95°F. was recorded at Greenwich and 94°F. at Cambridge and Margate. During the evening of the 27th temperature fell generally as the wind veered to NW. At Edgbaston (Birmingham) a drop of 20°F. was reported between 18h. 40m. and 20h. 10m. Thunderstorms occurred locally on the 19th to 21st, and 27th to 29th. Heavy rain was frequently associated with the thunderstorms, but otherwise rainfall measurements were very slight in England and only moderate in Scotland and Ireland. From the 19th to 27th was a very sunny period in England, among the larger amounts recorded were 15·0hrs. at Aberystwyth and Southport on the 22nd, 14·3hrs. at Skegness and 14·2hrs. at Greenwich on the 26th. On the 30th and 31st a depression passed across the British Isles giving heavy rain in south Scotland, gales locally on the coasts, and cool, cloudy, windy weather with slight rain generally in the west on the 30th and in the east on the 31st. The distribution of bright sunshine for the month was as follows:—

| | Total (hrs.) | Diff. from normal (hrs.) | | Total (hrs.) | Diff. from normal (hrs.) |
|---|---|---|---|---|---|
| Stornoway | 127 | —18 | Liverpool | 215 | +22 |
| Aberdeen | 164 | + 5 | Ross-on-Wye | 229 | +30 |
| Dublin | 171 | + 1 | Falmouth | 223 | — 2 |
| Birr Castle | 161 | +17 | Gorleston | 250 | +19 |
| Valentia | 148 | —11 | Kew | 244 | +43 |

The specal message from Brazil states that the rainfall in the northern and central regions was generally scarce with averages 0·75in. and 0·04in. below normal respectively, and in the southern regions irregular with an average 0·04in. above normal. Only three anticyclones passed across the country and there was a depression to the south. The crops were generally in good condition except in the central and southern regions where frosts affected the coffee and cocoa. At Rio de Janeiro pressure was 0·8mb. above normal and temperature 1·4°F. below normal.

*Miscellaneous notes on weather abroad culled from various sources.* Strong south-westerly winds and heavy rain occurred in Iceland on the 5th. A storm occurred over the Venice Lagoon on the 10th, and a brief but violent storm over Isola Bella (Lake Maggiore) just before midnight on the 14th, causing much damage to the famous Borromean Gardens. Heavy rains caused serious floods throughout south Germany during the first half of the month, much damage being done to the hay crops. A temperature of 94°F. was recorded in Berlin on the 28th, the hottest day of the year up to the end of July. Four people were killed in a heavy storm in the Pirna district in Saxony on the 29th. The 31st was the hottest day at Lisbon for 75 years, the maximum temperature recorded then being 104°F. (*The Times*, July 7th-August 2nd, *Berlin, Täglicher Wetterbericht*, and *British Daily Weather Report*.)

Excessive heat was experienced in the Red Sea early in the month. By the 11th the river level in the gorges of the Yangtze had topped the record at Wanhsien, but owing to fine weather floods did not follow. On the 6th and 13th it was reported that the monsoon was continuing very active in the Central Provinces and Berars, the United Provinces and in the Punjab, but elsewhere was weak. Heavy rains, however, fell in Bombay and Gujarat on the 15th and 16th, saving the cotton crop in these districts. The rains continued heavy during the rest of the month in western India and communications were interrupted through floods. Many casualties were caused by collapsing houses as well as by the widespread floods. (*The Times*, July 3rd-August 3rd.)

In the northern areas of the Canadian Prairies there was a fair amount of rain during the month, but in the southern areas the weather was dry and hot. Ontario and Quebec were suffering from drought at the end of the month. Temperature was below normal at first in the eastern United States but gradually the warm spell in the western districts extended also to the east. 100°F. was recorded at Albany on the 30th and at New York and Baltimore on the 31st. Twelve deaths from heat occurred in New York. At Fresno, California, 114°F. was recorded on the 27th. Rainfall was on the whole below normal though heavy rain occurred in the Gulf States during the week ending the 18th. The hurricane which did so much damage in Trinidad on June 27th travelled west-north-west doing much damage at Carupano, Venezuela. It then passed about 100-150 miles south of Jamaica striking Grand Cayman Island on July 1st. Owing to the excessive rain which accompanied it roads and bridges in Jamaica were damaged and crops largely destroyed in Grand Cayman Island. The hurricane passed about 300 miles west of Key West on the 4th and then moved across Texas during the night of the 6th-7th. Another hurricane passed Turks Island on the 27th seriously affecting the salt industry by the accompanying heavy rain. (*The Times*, July 3rd-August 3rd, and *Washington, D.C., U.S. Dept. Agric. Weekly Weathly and Crop Bulletin and Daily Weather Report*.)

## General Rainfall for July, 1933

| | | |
|---|---|---|
| England and Wales ... | 82 | per cent. of the average 1881-1915. |
| Scotland ... ... ... | 108 | |
| Ireland ... ... ... | 90 | |
| British Isles ... ... | 90 | |

## Rainfall: July, 1933: England and Wales.

| Co. | Station | In. | Per-cent. of Av. | Co. | Station | In. | Per-cent. of Av. |
|---|---|---|---|---|---|---|---|
| *Lond.* | Camden Square | ·92 | 39 | *Leis.* | Thornton Reservoir | 2·64 | 106 |
| *Kent* | Tenterden, Ashenden | 1·47 | 70 | ,, | Belvoir Castle | 1·76 | 72 |
| ,, | Folkestone, Boro. San. | 1·17 | ... | *Rut* | Ridlington | 1·24 | 49 |
| ,, | St. Peter's, Hildersham | ... | ... | *Lincs* | Boston, Skirbeck | 1·12 | 51 |
| ,, | Eden'bdg., Falconhurst | 2·34 | 102 | ,, | Cranwell Aerodrome | 1·69 | 73 |
| ,, | Sevenoaks, Speldhurst | 2·30 | ... | ,, | Skegness, Marine Gdns | ·75 | 34 |
| *Sus* | Compton, Compton Ho. | 2·97 | 105 | ,, | Louth, Westgate | 1·50 | 60 |
| ,, | Patching Farm | 1·49 | 62 | ,, | Brigg, Wrawby St. | 1·48 | ... |
| ,, | Eastbourne, Wil. Sq. | 1·48 | 68 | *Notts* | Worksop, Hodsock | 1·18 | 52 |
| ,, | Heathfield, Barklye | 2·88 | 115 | *Derby* | Derby, L. M. & S. Rly. | 1·95 | 82 |
| *Hants* | Ventnor, Roy. Nat. Hos. | 1·39 | 69 | ,, | Buxton, Terr. Slopes | 3·17 | 81 |
| ,, | Fordingbridge, Oaklnds | 1·78 | 89 | *Ches* | Runcorn, Weston Pt. | 1·69 | 61 |
| ,, | Ovington Rectory | 2·49 | 97 | *Lancs* | Manchester, Whit Pk. | 2·83 | 86 |
| ,, | Sherborne St. John | 1·44 | 65 | ,, | Stonyhurst College | 3·47 | 90 |
| *Herts* | Welwyn Garden City | 1·14 | ... | ,, | Southport, Hesketh Pk | 1·88 | 66 |
| *Bucks* | Slough, Upton | 1·55 | 81 | ,, | Lancaster, Greg Obsy. | 4·47 | 128 |
| ,, | H. Wycombe, Flackwell | 2·12 | ... | *Yorks* | Wath-upon-Dearne | 1·41 | 56 |
| *Oxf* | Oxford, Mag. College | 1·68 | 74 | ,, | Wakefield, Clarence Pk. | 2·29 | 90 |
| *Nor* | Pitsford, Sedgebrook | 2·53 | 107 | ,, | Oughtershaw Hall | 5·84 | ... |
| ,, | Oundle | 1·29 | ... | ,, | Wetherby, Ribston H. | 1·70 | 68 |
| *Beds* | Woburn, Crawley Mill | 1·49 | 67 | ,, | Hull, Pearson Park | 1·35 | 58 |
| *Cam* | Cambridge, Bot. Gdns. | ... | ... | ,, | Holme-on-Spalding | 1·27 | ... |
| *Essex* | Chelmsford, County Lab | ·93 | 44 | ,, | West Witton, Ivy Ho. | 2·77 | 105 |
| ,, | Lexden Hill House | ·93 | ... | ,, | Felixkirk, Mt. St. John | 2·46 | 90 |
| *Suff* | Haughley House | 1·35 | ... | ,, | York, Museum Gdns. | ·95 | 38 |
| ,, | Campsea Ashe | ·94 | 41 | ,, | Pickering, Hungate | 1·25 | 46 |
| ,, | Lowestoft Sec. School | ·93 | 41 | ,, | Scarborough | ·85 | 35 |
| ,, | Bury St. Ed., Westley H. | 2·83 | 113 | ,, | Middlesbrough | 1·64 | 64 |
| *Norf* | Wells, Holkham Hall | 1·05 | 45 | ,, | Balderdale, Hury Res. | ... | ... |
| *Wilts* | Devizes, Highclere | 3·02 | 130 | *Durh* | Ushaw College | 1·90 | 68 |
| ,, | Calne, Castleway | 2·00 | 83 | *Nor* | Newcastle, Town Moor | 1·61 | 61 |
| *Dor* | Evershot, Melbury Ho. | 3·24 | 128 | ,, | Bellingham, Highgreen | 2·23 | 68 |
| ,, | Weymouth, Westham | 1·76 | 98 | ,, | Lilburn Tower Gdns | 2·87 | 116 |
| ,, | Shaftesbury, Abbey Ho. | 2·65 | 103 | *Cumb* | Carlisle, Scaleby Hall | 3·50 | 107 |
| *Devon* | Plymouth, The Hoe | 2·61 | 95 | ,, | Borrowdale, Seathwaite | 10·00 | 127 |
| ,, | Holne, Church Pk. Cott. | 4·45 | 126 | ,, | Borrowdale, Moraine | 8·92 | ... |
| ,, | Teignmouth, Den Gdns. | 2·19 | 92 | ,, | Keswick, High Hill | 3·89 | 101 |
| ,, | Cullompton | 3·05 | 113 | *West* | Appleby, Castle Bank | 2·33 | 74 |
| ,, | Sidmouth, Sidmount | 2·74 | 109 | *Mon* | Abergavenny, Larch | 2·45 | 98 |
| ,, | Barnstaple, N. Dev. Ath | 1·85 | 69 | *Glam* | Ystalyfera, Wern Ho. | 6·14 | 134 |
| ,, | Dartm'r, Cranmere Pool | 5·20 | ... | ,, | Cardiff, Ely P. Stn. | 2·22 | 71 |
| ,, | Okehampton, Uplands | ... | ... | ,, | Treherbert, Tynywaun | 7·96 | ... |
| *Corn* | Redruth, Trewirgie | 2·81 | 92 | *Carm* | Carmarthen Friary | 3·41 | 97 |
| ,, | Penzance, Morrab Gdn. | 2·47 | 91 | *Pemb* | Haverfordwest, School | 2·39 | 75 |
| ,, | St. Austell, Trevarna | 3·28 | 98 | *Card* | Aberystwyth | 1·57 | ... |
| *Soms* | Chewton Mendip | 2·88 | 82 | *Rad* | Birm W.W. Tyrmynydd | 3·86 | 94 |
| ,, | Long Ashton | 1·96 | 69 | *Mont* | Lake Vyrnwy | 3·78 | 110 |
| ,, | Street, Millfield | 2·90 | 116 | *Flint* | Sealand Aerodrome | 1·19 | 50 |
| *Glos* | Blockley | 1·26 | ... | *Mer* | Dolgelley, Bontddu | 2·92 | 68 |
| ,, | Cirencester, Gwynfa | 2·39 | 93 | *Carn* | Llandudno | 1·35 | 56 |
| *Here* | Ross, Birchlea | 1·80 | 80 | ,, | Snowdon, L. Llydaw 9 | 15·02 | ... |
| *Salop* | Church Stretton | 2·04 | 82 | *Ang* | Holyhead, Salt Island | 1·42 | 54 |
| ,, | Shifnal, Hatton Grange | 3·04 | 135 | ,, | Lligwy | 1·59 | ... |
| *Staffs* | Market Drayt'n, Old Sp. | 2·47 | 92 | *Isle of Man* | | | |
| *Worc* | Ombersley, Holt Lock | 1·34 | 63 | | Douglas, Boro' Cem. | 2·06 | 67 |
| *War* | Alcester, Ragley Hall | 1·74 | 73 | *Guernsey* | | | |
| ,, | Birmingham, Edgbaston | 2·11 | 91 | | St. Peter P't. Grange Rd | 1·87 | 93 |

## Rainfall: July, 1933: Scotland and Ireland.

| Co. | Station | In. | Per-cent. of Av. | Co. | Station | In. | Per-cent of Av. |
|---|---|---|---|---|---|---|---|
| *Wig* | Pt. William, Monreith | 3·02 | 107 | *Suth* | Melvich | 4·39 | 157 |
| ,, | New Luce School | 3·12 | 92 | ,, | Loch More, Achfary | 5·09 | 95 |
| *Kirk* | Dalry, Glendarroch | 5·60 | 156 | *Caith* | Wick | 2·21 | 84 |
| ,, | Carsphairn, Shiel | 7·17 | 137 | *Ork* | Deerness | 1·25 | 49 |
| *Dumf* | Dumfries, Crichton, R.I | 3·37 | 109 | *Shet* | Lerwick | 1·99 | 87 |
| ,, | Eskdalemuir Obs. | 6·85 | 167 | *Cork* | Caheragh Rectory | 4·12 | ... |
| *Roxb* | Branxholm | 3·56 | 118 | ,, | Dunmanway Rectory | 3·84 | 98 |
| *Selk* | Ettrick Manse | 6·55 | 147 | ,, | Cork, University Coll. | 2·00 | 74 |
| *Peeb* | West Linton | 4·49 | ... | ,, | Ballinacurra | 2·30 | 82 |
| *Berw* | Marchmont House | 3·85 | 126 | *Kerry* | Valentia Obsy. | 3·94 | 104 |
| *E.Lot* | North Berwick Res. | 2·47 | 96 | ,, | Gearahameen | 6·40 | 111 |
| *Midl* | Edinburgh, Roy. Obs. | 4·78 | 169 | ,, | Killarney Asylum | ... | ... |
| *Lan* | Auchtyfardle | ... | ... | ,, | Darrynane Abbey | 4·17 | 114 |
| *Ayr* | Kilmarnock, Kay Pk. | 4·05 | ... | *Wat* | Waterford, Gortmore | 2·18 | 69 |
| ,, | Girvan, Pinmore | 4·44 | 122 | *Tip* | Nenagh, Cas. Lough | 2·62 | 83 |
| *Renf* | Glasgow, Queen's Pk. | 3·95 | 135 | ,, | Roscrea, Timoney Park | 2·45 | ... |
| ,, | Greenock, Prospect H. | 3·77 | 96 | ,, | Cashel, Ballinamona | 2·60 | 90 |
| *Bute* | Rothesay, Ardencraig. | 4·98 | ... | *Lim* | Foynes, Coolnanes | 2·89 | 94 |
| ,, | Dougarie Lodge | 3·94 | ... | ,, | Castleconnel Rec. | 2·97 | ... |
| *Arg* | Ardgour House | 8·30 | ... | *Clare* | Inagh, Mount Callan | 5·78 | ... |
| ,, | Glen Etive | ... | ... | ,, | Broadford, Hurdlest'n. | 3·37 | ... |
| ,, | Oban | 6·08 | 158 | *Wexf* | Gorey, Courtown Ho. | 2·30 | 78 |
| ,, | Poltalloch | 5·83 | 142 | *Kilk* | Kilkenny Castle | 1·86 | 66 |
| ,, | Inveraray Castle | 5·95 | 119 | *Wick* | Rathnew, Clonmannon | 2·28 | ... |
| ,, | Islay, Eallabus | 3·34 | 98 | *Carl* | Hacketstown Rectory | 2·97 | 86 |
| ,, | Mull, Benmore | 13·50 | ... | *Leix* | Blandsfort House | 2·64 | 84 |
| ,, | Tiree | 4·46 | 123 | ,, | Mountmellick | 2·91 | ... |
| *Kinr* | Loch Leven Sluice | ... | ... | *Offaly* | Birr Castle | 3·12 | 106 |
| *Perth* | Loch Dhu | ... | ... | *Kild'r.* | Monasterevin | ... | ... |
| ,, | Balquhidder, Stronvar | 3·44 | ... | *Dublin* | Dublin, FitzWm. Sq. | 1·67 | 65 |
| ,, | Crieff, Strathearn Hyd. | 3·28 | 110 | ,, | Balbriggan, Ardgillan. | 1·79 | 66 |
| ,, | Blair Castle Gardens | 2·70 | 105 | *Meath.* | Beauparc, St. Cloud | 2·53 | ... |
| *Angus.* | Kettins School | 2·63 | 101 | ,, | Kells, Headfort | 2·26 | 71 |
| ,, | Pearsie House | 3·13 | ... | *W.M.* | Moate, Coolatore | 2·71 | ... |
| ,, | Montrose, Sunnyside | 3·16 | 120 | ,, | Mullingar, Belvedere | 2·76 | 87 |
| *Aber* | Braemar, Bank | 2·69 | 105 | *Long* | Castle Forbes Gdns. | 3·99 | 128 |
| ,, | Logie Coldstone Sch. | 2·65 | 90 | *Gal* | Ballynahinch Castle | 5·34 | 129 |
| ,, | Aberdeen, King's Coll. | 3·08 | 110 | ,, | Galway, Grammar Sch. | ... | ... |
| ,, | Fyvie Castle | 3·44 | 106 | *Mayo* | Mallaranny | 4·36 | ... |
| *Moray* | Gordon Castle | 3·11 | 97 | ,, | Westport House | 3·14 | 101 |
| ,, | Grantown-on-Spey | ... | ... | ,, | Delphi Lodge | 7·77 | 117 |
| *Nairn.* | Nairn | 2·02 | 70 | *Sligo* | Markree Obsy. | 2·97 | 86 |
| *Inv's* | Ben Alder Lodge | 2·37 | ... | *Cavan.* | Belturbet, Cloverhill | 2·12 | 68 |
| ,, | Kingussie, The Birches | 2·50 | ... | *Ferm* | Enniskillen, Portora | ... | ... |
| ,, | Loch Quoich, Loan | 6·75 | ... | *Arm* | Armagh Obsy | 2·76 | 95 |
| ,, | Glenquoich | 2·14 | 33 | *Down* | Fofanny Reservoir | 4·13 | ... |
| ,, | Inverness, Culduthel R. | 3·23 | ... | ,, | Seaforde | 3·36 | 105 |
| ,, | Arisaig, Faire-na-Sguir | 4·83 | ... | ,, | Donaghadee, C. Stn. | 2·15 | 77 |
| ,, | Fort William, Glasdrum | ... | ... | ,, | Banbridge, Milltown | 2·44 | 75 |
| ,, | Skye, Dunvegan | 2·46 | ... | *Antr* | Belfast, Cavehill Rd. | 3·38 | ... |
| ,, | Barra, Skallary | 3·85 | ... | ,, | Aldergrove Aerodrome | 2·54 | 91 |
| *R & C* | Alness, Ardross Castle | 2·73 | 90 | ,, | Ballymena, Harryville | 2·53 | 74 |
| ,, | Ullapool | 2·59 | 82 | *Lon* | Londonderry, Creggan | 3·70 | 101 |
| ,, | Achnashellach | 5·28 | 103 | *Tyr* | Omagh, Edenfel | 2·62 | 77 |
| ,, | Stornoway | 2·49 | 82 | *Don* | Malin Head | 4·33 | ... |
| *Suth* | Lairg | 1·52 | 49 | ,, | Milford, The Manse | 3·25 | 98 |
| ,, | Tongue | 2·70 | 88 | ,, | Killybegs, Rockmount. | 4·92 | 112 |

# Climatological Table for the British Empire, February, 1933

| STATIONS | PRESSURE: Mean of Day M.S.L. (mb.) | PRESSURE: Diff. from Normal (mb.) | TEMPERATURE: Absolute Max. (° F.) | TEMPERATURE: Absolute Min. (° F.) | TEMPERATURE: Mean Values Max. (° F.) | TEMPERATURE: Mean Values Min. (° F.) | TEMPERATURE: Mean Values ½ max. and min. (° F.) | TEMPERATURE: Mean Values Diff. from Normal (° F) | TEMPERATURE: Mean Wet Bulb (° F.) | Relative Humidity (%) | Mean Cloud Am'nt (0—10) | PRECIPITATION: Am'nt (in.) | PRECIPITATION: Diff. from Normal (in.) | PRECIPITATION: Days | BRIGHT SUNSHINE: Hours per day | BRIGHT SUNSHINE: Percentage of possible |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| London, Kew Obsy. | 1015·6 | − 0·4 | 56 | 25 | 45·9 | 36·0 | 40·9 | + 0·8 | 37·2 | 85 | 7·3 | 2·65 | + 1·11 | 15 | 2·7 | 28 |
| Gibraltar | 1017·3 | − 2·7 | 71 | 37 | 62·7 | 48·4 | 55·5 | − 0·3 | 48·3 | 82 | 4·6 | 4·37 | − 0·14 | 10 | .. | .. |
| Malta | 1012·8 | − 3·3 | 63 | 42 | 58·8 | 50·5 | 54·7 | − 0·6 | 50·5 | 75 | 6·5 | 2·77 | + 0·57 | 14 | 5·3 | 49 |
| St. Helena | 1011·4 | − 0·5 | 72 | 59 | 69·7 | 62·0 | 65·9 | 0·0 | 62·8 | 94 | 9·1 | 1·93 | .. | 17 | .. | .. |
| Freetown, Sierra Leone | 1012·5 | + 1·7 | 90 | 69 | 86·5 | 74·4 | 80·5 | − 1·8 | 76·2 | 90 | 3·8 | 0·57 | + 0·27 | 3 | .. | .. |
| Lagos, Nigeria | 1009·9 | + 0·2 | 91 | 72 | 88·7 | 77·3 | 83·0 | + 0·5 | 77·0 | 85 | 5·2 | 2·05 | + 0·15 | 5 | 7·3 | 61 |
| Kaduna, Nigeria | 1010·4 | − 3·0 | 100 | 56 | 93·7 | 61·9 | 77·8 | + 0·9 | 59·3 | 40 | 3·8 | 0·00 | − 0·02 | 0 | 8·8 | 75 |
| Zomba, Nyasaland | 1007·2 | − 0·7 | 85 | 62 | 80·3 | 64·9 | 72·6 | + 0·6 | 67·2 | 75 | 7·3 | 4·97 | − 5·68 | 15 | .. | .. |
| Salisbury, Rhodesia | 1009·9 | − 0·6 | 87 | 51 | 78·9 | 57·4 | 68·1 | − 0·7 | 62·1 | 67 | 5·7 | 5·36 | − 1·46 | 12 | 7·4 | 58 |
| Cape Town | 1013·0 | − 0·4 | 105 | 53 | 80·3 | 60·4 | 70·3 | 0·0 | 60·7 | 73 | 3·3 | 0·27 | − 0·31 | 3 | .. | .. |
| Johannesburg | 1009·0 | − 0·3 | 91 | 45 | 81·9 | 56·9 | 69·4 | + 3·8 | 57·5 | 60 | 3·4 | 1·34 | − 3·88 | 11 | 8·9 | 68 |
| Mauritius | 1009·8 | − 1·2 | 89 | 68 | 85·3 | 72·5 | 78·9 | − 0·4 | 75·2 | 74 | 6·8 | 6·41 | − 1·99 | 18 | 7·4 | 58 |
| Calcutta, Alipore Obsy. | 1012·4 | − 0·9 | 88 | 52 | 83·3 | 63·9 | 73·6 | + 2·4 | 64·7 | 89 | 4·9 | 2·59 | + 1·60 | 3* | .. | .. |
| Bombay | 1011·2 | − 1·5 | 87 | 65 | 83·3 | 68·6 | 75·9 | + 0·2 | 67·5 | 75 | 1·2 | 0·00 | − 0·03 | 0* | .. | .. |
| Madras | 1012·0 | − 0·9 | 90 | 64 | 85·4 | 68·3 | 76·9 | − 0·8 | 72·2 | 84 | 3·4 | 0·00 | − 0·30 | 0* | .. | .. |
| Colombo, Ceylon | 1010·3 | − 0·5 | 89 | 68 | 86·2 | 72·0 | 79·1 | − 1·3 | 75·1 | 76 | 4·1 | 2·60 | + 0·66 | 8 | 8·3 | 70 |
| Singapore | 1009·5 | − 0·7 | 92 | 69 | 88·5 | 71·0 | 79·7 | − 0·5 | 74·6 | 75 | 4·9 | 1·92 | − 4·70 | 7 | 7·4 | 62 |
| Hongkong | 1016·3 | − 2·3 | 79 | 53 | 65·1 | 56·9 | 61·0 | + 1·9 | 56·2 | 77 | 8·6 | 0·10 | − 1·73 | 5 | 3·5 | 31 |
| Sandakan | 1009·7 | .. | 90 | 72 | 85·6 | 74·7 | 80·1 | − 0·1 | 76·3 | 85 | 8·1 | 16·21 | + 5·24 | 17 | .. | .. |
| Sydney, N.S.W. | 1010·3 | − 3·6 | 93 | 53 | 77·9 | 63·1 | 70·5 | − 0·8 | 63·9 | 66 | 5·9 | 0·23 | − 3·97 | 5 | 8·0 | 60 |
| Melbourne | 1011·9 | − 2·6 | 99 | 48 | 77·2 | 54·5 | 65·9 | − 1·7 | 58·2 | 60 | 5·1 | 0·23 | − 1·48 | 6 | 8·5 | 62 |
| Adelaide | 1013·2 | − 1·0 | 108 | 51 | 86·1 | 60·3 | 73·2 | − 0·8 | 60·5 | 39 | 2·6 | 0·18 | − 0·54 | 2 | 10·7 | 80 |
| Perth, W. Australia | 1017·0 | + 4·0 | 112 | 58 | 90·3 | 66·8 | 78·5 | + 4·4 | 64·9 | 45 | 2·4 | 0·11 | − 0·34 | 4 | 10·1 | 77 |
| Coolgardie | 1010·9 | − 1·6 | 113 | 56 | 97·3 | 65·0 | 81·1 | + 4·9 | 62·6 | 35 | 3·1 | 0·02 | − 0·83 | 1 | .. | .. |
| Brisbane | 1011·3 | − 1·2 | 98 | 60 | 86·1 | 67·4 | 76·7 | + 0·2 | 69·3 | 65 | 4·3 | 2·44 | − 3·90 | 4 | 9·0 | 69 |
| Hobart, Tasmania | 1007·6 | − 5·6 | 77 | 43 | 66·6 | 49·9 | 58·3 | − 4·0 | 52·0 | 59 | 6·2 | 1·50 | + 0·02 | 11 | 7·3 | 53 |
| Wellington, N.Z. | 1007·5 | − 8·3 | 78 | 50 | 67·3 | 56·9 | 62·1 | − 0·5 | 58·8 | 76 | 7·6 | 3·75 | + 0·61 | 10 | 5·8 | 42 |
| Suva, Fiji | 1007·0 | − 0·8 | 92 | 75 | 88·3 | 76·3 | 82·3 | + 2·0 | 77·6 | 81 | 6·4 | 12·51 | + 1·79 | 25 | 6·1 | 48 |
| Apia, Samoa | 1008·1 | − 0·3 | 89 | 72 | 85·9 | 74·9 | 80·4 | + 1·4 | 77·8 | 79 | 7·1 | 22·71 | + 7·42 | 24 | 6·0 | 48 |
| Kingston, Jamaica | 1015·7 | + 0·4 | 89 | 65 | 86·2 | 67·4 | 76·8 | + 0·3 | 64·8 | 81 | 2·7 | 0·00 | − 0·60 | 0 | 9·6 | 83 |
| Grenada, W.I. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Toronto | 1015·2 | − 2·8 | 46 | − 6 | 32·3 | 19·9 | 26·1 | + 5·0 | 22·1 | 69 | 4·9 | 0·99 | − 1·39 | 5 | 4·5 | 43 |
| Winnipeg | 1015·9 | − 5·9 | 39 | −42 | 9·0 | −12·8 | −1·9 | − 2·0 | .. | .. | 5·0 | 0·00 | − 0·74 | 0 | 4·5 | 45 |
| St. John, N.B. | 1010·2 | − 3·7 | 49 | 2 | 34·4 | 19·2 | 26·8 | + 6·9 | 23·2 | 81 | 7·0 | 3·15 | − 0·75 | 11 | 3·2 | 31 |
| Victoria, B.C. | 1020·8 | + 4·2 | 48 | 17 | 41·6 | 32·7 | 37·1 | − 3·4 | 33·6 | 81 | 7·2 | 2·80 | − 0·46 | 13 | 3·8 | 37 |