M.O. 339.

The Meteorological Magazine

Air Ministry :: Meteorological Office

Vol. 66
May, 1931
No. 784

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased directly from H.M. STATIONERY OFFICE at the following addresses: ADASTRAL HOUSE, KINGSWAY, LONDON, W.C.2; 120, GEORGE STREET, EDINBURGH; YORK STREET, MANCHESTER; 1, ST. ANDREW'S CRESCENT, CARDIFF; 15, DONEGALL SQUARE WEST, BELFAST; or through any Bookseller.

The influence of weather changes on the numbers of animals

By C. E. P. BROOKS, D.Sc.

The past few years have seen the publication of several zoological papers dealing with fluctuations in the numbers of animals, which are of great interest to meteorologists, and appear to open up a new field in the application of meteorological data to economic life. Unfortunately some of them are published in technical or natural history journals outside our usual range of reading, and it seems worth while to summarise a few of them here.

Although "plagues" of mice or voles have been recorded from time to time in different parts of the world for some centuries at least, the systematic study of their causes was begun only in the present century. An excellent account of the problems involved was given by C. S. Elton in 1924[1] and a shorter summary more recently in 1929.[2] These problems may best be illustrated by a concrete example, that of the lemmings of southern Norway. These small rodents habitually live in the mountains, but periodically they migrate in swarms into the lowland in autumn, crossing crowded streets and even marching with great speed and determination into the sea. All these migrants die, mostly of an epidemic disease. Elton remarks that "lemming-years in Norway have the status of great floods or terrible winters." They have occurred with great regularity every three or four years since at least 1860, the average interval from 1862 to 1909 being 3.6 years. The direct cause of the migration is over-population, and as such might be assumed to represent a purely biological cycle of reproduction. The difficulty is that either migrations or maxima of population occur in widely separated localities, not only in Scandinavia, but even in Greenland and Canada, either in the same year or in the following year. Exactly the same cycle, even to the years of maxima, was found by A. D. Middleton in British voles.[3] It would seem impossible for purely biological cycles to keep in step in such widely distant regions without some governing control, and Elton regards this control as climatic.

The data for Canada are not direct, but are inferred from the numbers of skins of Arctic fox taken by the Hudson Bay Company. The lemming is the principal food of the Arctic fox, and a large number of the latter implies a large number of lemmings in the preceding year. An analysis of figures for 65 years read off from one of the diagrams shows a periodicity in the number of skins of almost exactly 3·6 years, with an amplitude almost equal to the annual mean. The periodicity is obviously real. The Arctic fox skins show also a less definite periodicity of between ten and eleven years, which is much more clearly brought out in the returns of the Canadian rabbit or varying hare (*Lepus americanus*) and the lynx which feeds on this animal. The periodicity in the numbers of skins of these two animals taken by the Hudson Bay Company is extraordinarily well marked, the curve rising steeply from zero to a maximum and falling again to zero in a manner closely resembling the sunspot curve. The rabbit shows another peculiarity; the number of young in a brood and of broods in a season also varies very definitely according to the year of the cycle. This he thinks cannot be due to physiological causes but must represent a corresponding cyclic variation of the environment. There are probably corresponding variations in the broods of other animals.

Most other animals about which for any reason (usually economic), data are available show similar periodic fluctuations, but the beaver forms a marked exception. This Elton regards as confirming his belief that the cause of the cycles in the other animals is climatic, as the beaver is independent of minor climatic fluctuations, for it lives on the bark of trees, and regulates its water-supply by building dams. Moreover fluctuations in the numbers of insects rarely—the cockchafer is an exception—show such regular periodicity, probably because, as shown by B. P. Uvarov,[4] they are more susceptible to meteorological "accidents" over a short period (a day or night to a few weeks) than to average conditions over a longer period. An excellent example of the effects of a single outstanding—and presumably not periodic— meteorological event, namely, the drought of 1921, on the numbers of fresh-water mollusca in eastern England has recently been published by Dr. A. E. Boycott.[5]

Now Elton remarks that the area over which mouse and lemming cycles tend to come in the same years—northern Labrador, Baffin Land, north-west Hudson's Bay, Scandinavia as far east as Finmark, the British Isles and probably Greenland—is precisely the area which is influenced by the Icelandic minimum, and he suggests that some climatic cycle acts on this low pressure area as a whole, possibly affecting rainfall or snowfall. That such a cycle cannot be clearly seen in the actual records of precipitation he does not regard as an insuperable objection, for the effects on mammals are cumulative and small irregularities or temporary fluctuations are smoothed out. As an illustration he cites lake-levels, which show periodicities much more clearly than do rainfall records, because they integrate the latter over time and space. The greater the degree of integration, the more clearly does the periodicity show up; thus the lynx, which feeds on the rabbit, shows a more regular periodicity of numbers. Moreover prolific animals, such as lemmings, mice or rabbits, have a natural biological cycle, increasing in numbers for a few years until over-population ensues and the great majority of the animals are killed off by some cause such as epidemic disease. If this biological cycle nearly coincides with a climatic cycle, it will be accentuated by a sort of resonance effect.

This is plausible enough, but there are difficulties. There is a weather periodicity of 3½ years in the Atlantic district, though one would not regard it as having either sufficient regularity or sufficient amplitude to be very potent biologically. Moreover the catches of fish in British seas, which B. Storrow[6] regards as directly connected with large scale movements of Atlantic waters and hence with the long-period or integrated barometric situation in the Atlantic, show no definite indications of a 3.6 year periodicity. The periodicity of the lynx is even less satisfactory. It is natural to look to the sunspot cycle as the cause, but the length of the lynx cycle, barely ten years, differs too much from the sunspot cycle. The dates of maxima in the former, and their place in the sunspot cycle (reckoned as number of years before or after a sunspot maximum) are as follows:—

Lynx maxima ...	1831	1839	1848-9	1859	1868	1878	1907
Sunspot maxima	1830	1837	1848	1860	1870	1883-4	1905
Years + or − ...	+ 1	+ 2	0	− 1	− 2	− 5	+ 2

There is no trace of regulation; the two cycles go their own ways quite independently, whereas if Elton's argument from the broods of the rabbit is correct, one would expect a very close parallelism indeed. It seems more likely that such a deep-seated physiological cycle is of ancient origin, and has become engrained in the Canadian rabbit in the course of ages, than that it is an *ad hoc* adjustment to contemporary environment. On the other hand the agreement between the lengths of the cycles of lemmings and mice suggests some common influence, and there is a possibility that the cycles were built up gradually in response to the average lengths of weather periodicities, at a time perhaps when these were more marked than at present.

There still remains the agreement of phase between north-eastern North America and north-western Europe, and for this it is difficult to see any alternative to Elton's theory of climatic control. It does not seem certain however that this control is necessarily periodic. It is the highly abnormal seasons that are by far the most effective (cf. ref. 5), and it is in these also that the abnormalities extend over the widest area. The mechanism is possibly somewhat as follows: the cycle may get a year out of step, so that when Norway is fully populated with lemmings Canada could still carry another year's increase with normal climatic conditions. If the next season is bad, in effect both countries are over-populated, and in both the numbers are drastically reduced, so that the cycle recommences at the same phase in both. The same result would follow an abnormally good season, which would enable Norway to carry its surplus lemming population for another year, giving it so to speak an overdraft on the bank of nature; again with the return to normal conditions the population would be reduced in both countries simultaneously. This is only a suggestion, but the problems merit further conjoint research by zoologists and meteorologists, for their intrinsic interest as well as for their economic importance.

REFERENCES.

1. ELTON, C. S. Periodic fluctuations in the numbers of animals: their causes and effects. *Edinburgh, Brit. J. Exper. Biol.*, 2, 1924-5, *pp.* 119-63.
2. ELTON, C. S. The relation of animal numbers to climate. *Conference of Empire Meteorologists*, 1929, *Agric. Sec.*, *pt.* 2, *pp.* 121-9.
3. MIDDLETON, A. D. Cycles in the numbers of British voles (Microtus). *Cambridge*, *J. Ecol.*, 18, 1930, *pp.* 156-65.
4. UVAROV, B. P. Weather and climate in their relations to insects. *Conference of Empire Meteorologists*, 1929, *Agric. Sec.*, *pt.* 2, *pp.* 130-47.
5 BOYCOTT, A. E. A re-survey of the fresh-water mollusca of the Parish of Aldenham after ten years with special reference to the effect of drought. *Repr. from* : *Trans. Hertfordshire Nat. Hist. Soc.*, *vol.* 19, *pt.* 1.
6. STORROW, B. Cullercoats herring investigations and their relation to other marine work: an essay on fluctuations. *Durham*, *Proc. Univ. Durham Phil. Soc.*, 8, 1930, *pp.* 191-238.

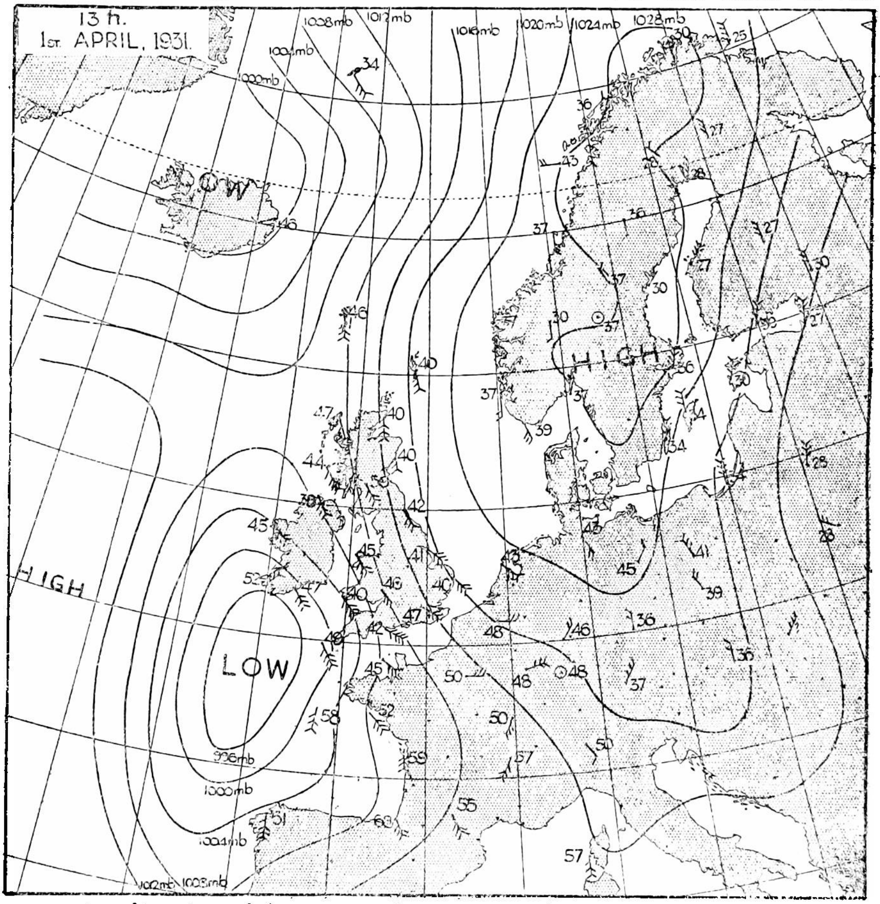
A noteworthy spell of dry air over England

The period March 29th to April 1st, 1931 (inclusive), deserves notice, meteorologically, by reason of the exceptional dryness of the air over a considerable part of England.

The first signs of this dryness made their appearance in the 13h. reports on March 29th, when Kew and Farnborough reported relative humidities of 35 per cent. approximately. March 30th indicated an intensification of the dryness and a slow spreading of the very dry air northward and westward: at 13h. on that day the relative humidity was approximately 25 per cent. at Kew, Croydon, Cardington and Farnborough and approximately 35 per cent. at Upper Heyford and Leafield. March 31st involved a further spreading northward and westward with Cranwell and Birmingham giving at 13h. relative humidities of approximately 35 per cent., a figure that was roughly the prevailing one over the whole of the inland parts of south-eastern England. The culminating dryness was, however, reached on April 1st, when some quite abnormally low readings of relative humidity were recorded, coupled with a further spreading of the dryness north and west. Selected figures that speak for themselves are a relative humidity of 15 per cent. (approximately) at Cardington at 12h. 30m., of 19·5 per cent. at South Kensington at noon, of 24 per cent. at Ross-on-Wye at 13h., of 25 per cent. (approximately) at Harrogate, Kew, Croydon, Farnborough, Leafield and Upper Heyford at the same hour, and of 25.8 per cent. at Grayshott at 12h. 45m. But following this maximum peak of the dryness there came very quickly the break-down, and by late evening on April 1st the spell of dry air was broken and relative humidities were back to the normal eighties and nineties, there to continue.

The synoptic conditions producing the dryness merit attention. On March 29th, a large anticyclone covered the whole of the North Sea. On the 30th this high pressure system became centred over Scandinavia with a connecting tongue going on to a less intense "high" off south-west Spain. On the 31st the main system remained over Scandinavia, but both the tongue and the "high" off south-west Spain moved eastward before the advance of a large depression off Ireland. On the 1st the retreat eastward of the tongue and the Spanish "high" continued as did the advance eastward of the Irish "low," while the Scandinavia "high" remained unchanged. By 7h. on the 2nd, however, this Scandinavia "high" had also began to move eastward whilst the "low" was centred over the Bay of Biscay and had the whole of the British Isles within the ambit of its isobars.

During, therefore, the four days, March 29th to April 1st, the air stream over eastern and south-eastern England and the Midlands had come from the far northern regions near Spitsbergen and had travelled southward over Scandinavia or western Russia and over Germany as a north wind before it turned west to cross the southern North Sea, France, and the eastern English Channel as a south-east one. That long track from the north meant that the air was originally cold but became warmed in its movement to more southerly latitudes, and that the long track was also a long land track meant that it had had little or no



opportunity to pick up moisture on the way. In these two factors, then, working together, lies the reason for the extremely low relative humidities experienced over much of England in the period under review.

The attached diagram shows the synoptic chart for 13h. on April 1st—the day of greatest intensity of the dryness—and a consideration of it will illustrate the nature of the air track to which reference has already been made.

William H. Pick.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, April 15th at 49, Cromwell Road, South Kensington. Mr. R. G. K. Lempfert, M.A., F.Inst.P., President, in the Chair.

W. D. Flower, B.Sc.—An analysis of the cold front over Egypt on March 7th, 1929.

The cold front associated with a depression which passed across Egypt on March 7th, 1929, was analysed, using the usual autographic record of wind, temperature, humidity and pressure at Heliopolis and Ismailia, together with records of the vertical temperature gradient at the latter station. The cold air was shown to have advanced in the form of a wedge with its nose above the surface at Ismailia, but as a flat wedge on the surface at Heliopolis.

W. H. Pick, B.Sc.—A note on the relationship between fog and relative humidity.

The fogs occurring at synoptic hours at Cardington during the years 1929 and 1930 were examined, and it was shown that the majority of them were accompanied by unsaturated air as determined by readings of the dry and wet bulb thermometers. This concurrent occurrence of unsaturated air was independent of the intensity of the fog, even the majority of the very thick fogs being so accompanied. Interesting speculations are thus raised. An appendix gives details of fogs occurring at sea with distinctly unsaturated air, thus confirming the ideas of Dr. J. S. Owens.

H. Jameson, B.Sc.—Temperature observations on Adam's Peak, Ceylon.

Observations of temperature made at the summit of Adam's Peak, Ceylon, altitude 7,360 feet, on 23 days in January and February, 1930, were discussed and compared with simultaneous observations at Nuwara Eliya, a valley station at 6,170 feet. The night temperatures showed the normal differences between a valley and a peak site. During the day, however, there was a sharp rise of temperature in the morning, lasting till about 11 a.m., and giving much higher temperatures than might be expected at that altitude. This was followed by a steady fall, till the constant night temperature was reached about 6 p.m. It was suggested that these day temperatures were due to mountain winds converging up the Peak in the morning, and forming cloud over it before midday.

S. P. Wiltshire.—The correlation of weather conditions with outbreaks of potato blight.

Correspondence

To the Editor, *The Meteorological Magazine.*

An early Scottish Meteorologist

Thomson's Biographical Dictionary of Eminent Scotsmen (last edition 1875) has the following interesting details of the first person in Scotland to possess a barometer.

This was a Mr. David Gregory who lived near Aberdeen in the early part of the seventeenth century. He was the father of David Gregory, the able commentator on Newton's *Principia* and Savilian Professor of Astronomy at the University of Oxford. The elder Gregory, it appears, was originally a merchant but soon renounced all commercial pursuits, devoting himself entirely to the cultivation of science, studying chiefly mathematics and experimental philosophy.

In the account concerning him we read that, "Mr. Gregory's pursuits caused him to be noted throughout the whole country, and as he was the first person in Scotland who possessed a barometer, from which he derived an extensive knowledge of the weather, it was believed that he held intercourse with the beings of another world." So widely had this belief concerning him been circulated, that a deputation from the presbytery waited on him, and it was only by a fortunate chance that he escaped from undergoing a trial for witchcraft. He had acquired an extensive knowledge of medicine, and was in the habit of practising in the district without fee in all cases. It was this circumstance alone which prevented the reverend members of the presbytery from "calling him to account for his superior intelligence."

J. HARROWER.

95, *St. John's Road, Corstorphine, Edinburgh.* *April* 11*th*, 1931.

Exceptional Rain at Tungchwan, West China

In connexion with the article on Tungchwan in the March number of the magazine, the following meteorological items in a letter from Dr. Lucy E. Harris, Friends Mission, Tungchwan, Sze, W. China, dated July 7 *et seq.*, 1930, are of interest.

"Last Sunday night (*i.e.*, July 5-6th) we had a most phenomenal rainfall and thunderstorm, the like of which have not been seen in Tungchwan before (*i.e.*, about 25 years, possibly more). It began about 8.30 p.m. and kept on till morning with thunder and lightning almost the whole time and the rain coming down in torrents. It was almost impossible to sleep, the noise was so great. Unfortunately I could not measure the total amount as my rain-gauge only takes between 4 and 5 inches. It was quite full, but I do not know how much was lost. In the morning this house compound was like a lake, and the men's compound, which is lower, was still worse. The water was over a foot deep in the men's waiting room."

J. EDMUND CLARK

Street, Somerset. *March* 24*th*, 1931.

Limits of Visibility

The great distances at which objects can be seen under favourable meteorological conditions and in an atmosphere free from atmospheric pollution are well illustrated by the following extracts from notes recently received from Mr. Seton Gordon of Duntulm Lodge, Isle of Skye. The distances in miles have been inserted in brackets. Speaking of Saturday, November 29th, 1930, a " most beautiful day," he says, " a friend and I were on the summit of Beinn Edra. The thing which most impressed me was that I could (through the glass) see the swell breaking beneath the Rudha Stoer lighthouse, which seems about 56 miles from where I stood. I could see Handa (67 miles) quite plainly. West I could actually see the sun shining on the edge of the great precipice of Conachair on Hirta (87 miles), and on the neighbouring isle of Boreray I could see the two Stacks—Stac an Armuinn and Stac Lii. South I could see the northwest hill of Tiree (77 miles) and Hyskeir Light. Over North Uist I could see the Monach Lighthouse quite plainly (55 miles). . . . . . St. Kilda (87 miles) is always visible from that hill when visibility is really good." In the second note Mr. Seton Gordon remarks, " St. Kilda is always visible from the Cuillin Hills (95 miles) in very clear weather. . . . . . The longest views I have had are (1) the Paps of Jura (92 miles) from Sgurr na Banachdich (Cuillin), (2) the Paps of Jura (107 miles) and Ben Nevis (92 miles) from Hecla of South Uist."

Several of the examples enumerated above approach the limit of visibility as determined by the curvature of the earth and the heights of the objects and points of observation. They therefore suggest that if objects of suitable height were available in these districts they could be seen at even greater distances. Clouds may indeed occasionally be seen at greater distances. The present writer, on the afternoon of July 16th, 1930, on board s.s. *St. Magnus*, between Lerwick and Aberdeen, saw very clearly the tops of cumulus clouds which almost certainly were lying over the Norwegian coast, some 200 miles distant. The tops emerged above a line of haze just appreciably above the sea horizon. Allowing for an average amount of atmospheric refraction the cloud tops on that afternoon were apparently about 20,000ft. above sea level.

A. H. R. GOLDIE.

6, *Drumsheugh Gardens, Edinburgh. December* 10*th*, 1930.

The following letter, written by Mr. G. D. Simpson, Master Mariner, to the *Daily Mail*, is of interest in this connexion :—

At daybreak, 5.30 a.m. on November 23rd, in latitude 29° 54′ N., longitude 18° 49′ W., Teneriffe Peak, Canary Islands, was visible to the naked eye at a distance of 150 miles, bearing 130°. This, I believe, is the farthest distance on record at which the peak has been sighted. The altitude of its summit above the horizon was in accordance with that of an object 12,000ft. high (approximately the height of Teneriffe Peak) viewed from a distance of 150 miles by an observer 50ft. above sea level. This proves that the unusual visibility of the peak was not due to mirage.

Aurora Borealis—Aldergrove

The evening of Saturday, December 20th, 1930, was marked by a display of the aurora borealis, the brightest seen from this or any other district within the memories and experiences of its observers—Messrs. D. H. Clarke, W. L. Baxter and myself. The description given below is a combination of our three independent observations from various points and at different times.

Stratus, strato-cumulus (1,500ft.) and high strato-cumulus clouds, which had almost completely covered the sky during the afternoon, cleared rapidly from 17h. 40m., G.M.T., onwards until, at 18h. 30m. there was but a trace of the lower clouds remaining.

The aurora was first seen about 18h. 14m., it was a well defined arch of misty glow with sharp upper and lower edges from the horizon to its crest, brilliant enough to light up the country side and make the northern stars appear dim. Distant trees and other objects could be seen clearly, and a small cap of cloud over hills to west-north-west palely reflected its light. Figure 5, facing page 26, of the "Meteorological Glossary" (2nd Ed., 1930) gives an idea of the arch seen, but without the upward streamers shown in this sketch.

While riding towards Antrim town, it was noticed that the crest of the arch was well to westward of true north: any rapid movement in the bow could not be detected owing to one's own motion and the aurora's nebulous texture, but occasional pendants or downward streamers were seen in both the eastern and western halves. Gradually the western portion lost its marked upper and lower boundaries and became more curtain-like and of greater vertical depth. About 18h. 30m. there were three distinct horizontal breaks in the extreme western section, while the eastern end kept its sharp definition—not unlike a searchlight beam, only, of course, curved. A rough measure of the aurora's brilliance was given by comparison with the cloud reflected light of Belfast some 13 miles in a direct line to south-eastwards, to which it was quite equal.

Throughout the whole of the display there was in the western half a gently curved depression in the upper edge and it seemed to be moving slowly towards north. The phenomenon faded about 18h. 55m., no colours were seen, only a whitish glow: the positions in this description were checked against *Ursa Major* and *Stella Polaris*.

C. VAUGHAN STARR.

R.A.F. Station, Aldergrove. January 3rd, 1931.

NOTES AND QUERIES

Salinity of Rainwater

The question recently arose in connexion with the rusting of iron pipes of anemometers as to the salinity of the rainwater at different places in the British Isles. Through the courtesy of Sir John Russell, F.R.S., Director of the Rothamsted Experimental Station, monthly values of the salinity of the rain collected at Valentia Observatory from November, 1912, to November, 1916, have been received. The values were determined by the late Mr. N. H. J. Miller.

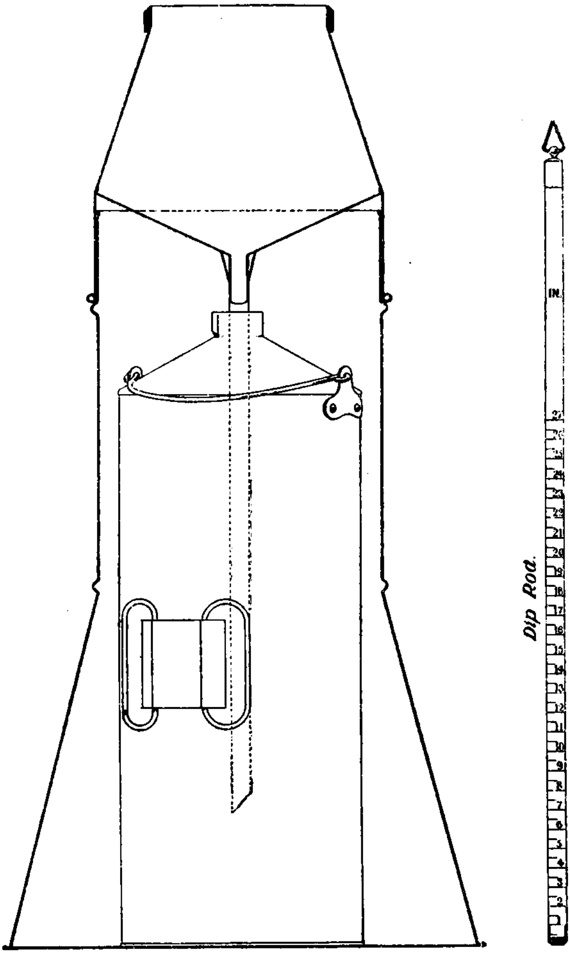
The monthly values have been compared with different quantities, viz., the total amount of rain, the percentage frequency of winds from land and from sea directions and the percentage frequency of winds of force 6 and over, irrespective of direction. The examination shows that there is little connexion between the percentage of salt and the quantities examined, with the exception of the last, viz., percentage frequency of winds of force 6 or more. With this quantity, however, there is a very close connexion.

The correlation coefficient between the percentage of strong winds and the percentage of salt (chlorine) in rainwater based on the values for the whole period is $+0{\cdot}72 \pm 0{\cdot}046$.

It is hoped to publish shortly a fuller discussion of the results.

New "Octapent" mountain rain-gauge

There are many parts of the country, particularly in mountainous regions, where an accurate knowledge of the rainfall is of the utmost importance in connexion with water supply schemes and hydraulic engineering, in which, owing to the absence of human habitation, the daily reading of a rain-gauge is impossible. It is frequently possible in these circumstances to arrange for the placing of gauges in suitable sites which can be visited monthly by an observer, the gauges being designed to hold the largest quantity of rain which is likely to fall in any individual month. Gauges employed for this purpose in the past have been of the "Bradford" and "Seathwaite" types, the former being in most common use. The Bradford gauge in its original form resembles the ordinary 5-in. Snowdon in shape, but it has a deep container capable of holding 15in. of rain. This capacity is insufficient for a monthly gauge even in only moderately wet situations. The "Seathwaite" gauge has a capacity of over 40in. and this is unnecessarily large, except in very wet situations. To meet the need for average moorland exposures Bradford gauges with a capacity of 27in. have been used. Satisfactory results are given by these gauges, but there are difficulties in their use, in that a hole of considerable depth is needed to bury the lower part of the gauge. In mountainous country the " soil " frequently consists of rock and there may be difficulty in providing a hole for the gauge in a spot where it is otherwise desirable that it should be placed. Further difficulty occurs in measuring the amount of water collected. The can is about 3ft. long and weighs, when full, some 23lb. It is not easy to handle this and to pour the water into a glass measure without considerable risk of spilling it. It recently occurred to Mr. E. G. Bilham that this difficulty could be overcome and a very effective mountain rain-gauge made by combining a 5-in. rim with an 8-in. container, thus providing in a compact space a large volume for the water received through a 5-in. rim. A gauge which has been made up for the Meteorological Office by Mr. W. Rollason in accordance with this proposal, is illustrated in the attached drawing. The outside dimensions of the gauge are little larger than in the splayed base Meteorological Office pattern 8-in. gauge and the container into which the water is received measures 18in. by 7in. It holds 27in. of rain without overflowing. When full of water it necessarily weighs as much as the container in the 27-in. " Bradford " gauge, but its shape renders it much easier to handle. Except for the brass rim and the can fittings, the gauge is made entirely of copper. There are no external seams in the funnel and a fruitful source of trouble in rain-gauges is, therefore, eliminated. The gauge is provided with



OCTAPENT RAINGAUGE.

a dip rod for rough preliminary check readings, a glass measure of 2-in. capacity being used for the actual measurements. It is proposed to call this gauge the "Octapent" rain-gauge, the name suggesting that the new gauge combines some of the features both of the 8-in. and the 5-in. gauges. It appears probable that it will meet the need for a mountain gauge suitable for average conditions in a more satisfactory manner than has previously been possible, and although not yet on the market, its design has already created considerable interest.

The Deepening of Depressions by Day and Night

The difficulty expressed by Major Goldie* "in seeing why the normal pressure variation should be associated so markedly with the variations of rainfall . . . . ." does not appear to exist for the Norwegian meteorologists, if one may judge from a recent paper.† On p. 69 of that publication it is stated that the simplest and most probable explanation of the semi-diurnal pressure wave is that it is determined by the "moist-labile" rainfall reinforced by the resonance of the atmosphere. Refsdal, it may be noted, also quotes views of A. Schmauss‡ that near the turning points of the daily pressure curve are critical periods in regard to the setting-in of depressions.

S. T. A. MIRRLEES.

Alto-cumulus formed by an aeroplane

At about 15h. 10m., G.M.T., on January 14th, 1931, at South Farnborough, Hants., my attention was called to a trail of white cloud that was apparently being emitted by an aeroplane flying at about 12,000 feet. After watching the evolutions of the machine for a few minutes I came to the conclusion, as did most other observers, that it was a usual "sky writing" experiment. I was thus considerably surprised about an hour later to hear that the trail had been formed unintentionally, and further, that another pilot had had the same experience. The second pilot whilst climbing noticed that a white cloud which was apparently being emitted from another aeroplane above him, suddenly ceased as the latter continued its climb. On arriving at the height of this white cloud, 13,000 feet (uncorrected), a similar trail which had begun to form behind his machine ceased abruptly as he gained height. So he descended to 13,000 feet again, the phenomenon reappeared, and he found that it was possible to form quite a dense cloud layer provided that he kept within a layer of about 400 feet vertical thickness. On looking to the left the cloud

* *London, Meteorological Magazine*, 66, 1931, p. 66.

† Der Feuchtlabile Niederschlag. By A. Refsdal. *Oslo. Geofys. Publ. V. No. 12. 1930.*

‡ Die Lebensdaten der Mitteleuropäischen Depressionen I. *München Meteor. Jahrb. 1923.*

appeared to form a few feet behind the trailing edge of the wings in a line with the propeller tip, but unfortunately he omitted to notice whether a similar formation was present on his right. No details are available from the first pilot. From the ground two distinct streams, which appeared to originate from the sides of the aeroplane, could be detected. These appeared to unite into a single billowy stream at a distance behind the machine equal to twice its length and after a very short interval the whole cloud simulated a band of alto-cumulus. The only way it could be detected from other banks of alto-cumulus was in its apparent greater brightness. The difference may be likened to that between old and new paintwork. Once formed the cloud moved southward in the general northerly current prevailing at that height and was still visible about an hour afterwards.

The temperature as given by a strut thermometer was – 2°F., but unfortunately no humidity readings are available. Up to 15h., G.M.T., the sky had been entirely clear, but at the time of these ascents banks of alto-cumulus clouds were forming and spreading over the sky from the north at the precise height (13,000 feet). The synoptic chart for 13h., G.M.T., on January 14th, 1931, indicated that a milder north-westerly surface current associated with a depression near Iceland was spreading south-eastwards across the country, but there were no indications from the upper air temperature data that a warmer moist layer existed above 13,000 feet. A nephoscope reading shows the alto-cumulus drifting from 360° at about 45 m.p.h., while the wind at 11,000 feet as determined at Cardington at 12h., G.M.T., was from 15° at a speed of 61 m.p.h.

Possible reasons for the formation are (1) the sudden cooling of saturated air due to reduction of pressure (*a*) immediately behind the leading edge of the aeroplane, (*b*) in front of the propeller, (2) mechanical disturbance and precipitation of a supercooled layer, and (3) emission of nuclei and water vapour from the two exhausts (located on each side of the machine and terminating in front of the wings). In the first case, four streams or series of vortices, appearing to originate at the wing tips, would be expected. In the second and third cases there seems no apparent reason why the cloud should be confined to a stream on each side of the aeroplane unless the formation is dependent upon the addition of nuclei and water-vapour. This appears to be the most likely explanation.

W. H. BIGG.

Reviews

The Areas Covered by Intense and Widespread Falls of Rain. By J. Glasspoole. Proc. Inst. Civil Engineers. 229, 1929-30, pp. 137-194.

For engineering purposes two distinct types of information about rainfall are needed. The water engineer entrusted with the responsibility of a town's water supply needs to know how much water he can expect to obtain from his gathering ground. His main concern is the average rainfall, and his needs are therefore met if he has access to records showing the actual annual fall at a sufficient number of points in the gathering ground over a period of years. The engineer who has to deal with a drainage system, however, needs information of a different type. To him, heavy falls occurring in short periods are of chief importance since it is they which may cause the damage by flooding which it is his business to minimise. The term "short period" may mean anything from a few minutes to several days according to the scale of the drainage system under consideration. Thus a street drain may be inadequate to deal with a fall of one-fifth of an inch occurring in five minutes, because the "time of concentration" of the water running off the area served by the drain is very small. On the other hand the time of concentration of the run-off to the main out-fall of the complete drainage system of a large town may be several hours and in a river basin it may be several days. It is clear therefore that information as to the maximum probable falls in periods varying from a few minutes to several days must be available if a drainage system is to be properly designed at all points. Since falls of great intensity are often highly localised it is equally important that information as to the area over which they extend should also be available.

The annual volumes of *British Rainfall* contain sections giving particulars of "heavy falls in short periods" and "heavy falls on rain days." In recent years it has been customary, also, to give measurements of the areas enclosed by successive isohyetal lines in the case of the most noteworthy falls. In addition, a number of rainstorms of outstanding interest have been discussed in detail in separate papers printed either in *British Rainfall*, the *Meteorological Magazine* or the *Quarterly Journal of the Royal Meteorological Society*. A good deal of information bearing on drainage problems has thus become available, but it has not hitherto been collected together in a form suitable for ready consultation by an engineer. Dr. Glasspoole's paper thus meets a very real need, and it may be added that the information given in it is of considerable interest to meteorologists as well as to engineers.

In the first part of the paper particulars are given of the areas covered by heavy falls of specified magnitude during two or more rainfall days. As an example of the information given we may quote the data relating to the Norwich floods of August 25th and 26th, 1912. During the two rainfall days we learn that the fall exceeded 8in. over 18 sq. miles, 7in. over 259 sq. miles, 6in. over 705 sq. miles, 5in. over 1,039 sq. miles, 4in. over 1,939 sq. miles, 3in. over 3,463 sq. miles, and 2in. over 7,462 sq. miles. In the next section similar information is given for a number of remarkable falls on single rainfall days. Falls in shorter periods down to about two hours are then considered and in the descriptive matter relating to particular falls details are given of some of the more remarkable intensities over periods down to two minutes. The paper concludes with a discussion of types of intense and widespread rains. Like other rains these unusual falls may be classified under "orographic," "cyclonic" and "convectional." Heavy orographic rains are confined to the mountainous districts of the west and north; convectional rains reach their maximum development in the central and eastern districts, but any part of the British Isles may be visited by a heavy cyclonic fall and the most heavy and widespread falls are of this type. Nevertheless, Dr. Glasspoole finds that over a considerable area of the British Isles a fall exceeding 4in. in a day has never been recorded. The counties concerned fall into two well-defined groups; the first includes most of Ireland, the south-west of Wales and Cornwall; the second includes the Midlands of England, Gloucester, Hereford, Worcester, Warwick, Rutland and Derby. The author is of opinion that this immunity represents a definite climatic factor. Having regard to the fact that cyclonic systems have in the past given falls exceeding 7in. in a rainfall day in counties as far apart as Somerset and Norfolk, however, it seems possible that some revision of this conclusion may eventually be called for.

E. G. Bilham.

Climate, A treatise on the principles of weather and climate. By W. G. Kendrew, M.A. Size 8½ × 5½in., pp. ix+329, *Illus.* Published by Mr. Milford, at the Clarendon Press, Oxford, 15s. net.

Mr. Kendrew, who is well known as one of the few authors to produce a work on climatology in the English language, in his latest book views the subject of climate from a different angle. This book is described in the preface as written primarily for the general reader who wishes to know something of the principles of weather and climate and for those workers who find a knowledge of climatology desirable for the furtherance of their main subject of study. After a short introductory chapter, parts II to VI deal with the following subjects: insolation and temperature; pressure and winds; humidity, rainfall, evaporation, clouds, thunderstorms; sunshine and cloud; fog; the 36 chapters giving explanations of the principles involved and also interesting practical applications. The numerous clear maps, diagrams and reproductions of autographic records are a praiseworthy feature. Parts VII to X deal with mountain and plateau climate; the weather of temperate regions; local winds; some climatic types. The reproductions of synoptic charts are extremely interesting, and the reader who studies these carefully will gain a considerable insight into some of the peculiarities of the weather of this country. These charts deal with events recent enough to be well within the memory of the reader, for example gales in November, 1929, or heavy snow in south of England, December, 1927. Of the photographs, those of the Matterhorn and of a tornado cloud may be mentioned. The printing is done in the usual excellent style of the Clarendon Press, so that one is the more surprised to see a few misprints (" Saragossa Sea," perhaps, but " rain guages " at least should not occur in a meteorological book). The book is written in a clear and interesting style and is in most respects abreast of recent developments. The case for and against the polar front theory is stated, ultra-violet radiation, atmospheric pollution, humidity and temperature in relation to the human body are dealt with. On the whole, the book may be cordially recommended to the general reader. To the other class for whom the author writes, the plan may make it less suitable for quick reference, information about " Mediterranean climate," or " westerlies," for example, having to be sought under the separate headings of pressure and winds, rainfall, sunshine and so on. There are two chapters, " The Wind Systems of the Globe " and " The Major Regions of Pressure and Winds," in which opportunities have been missed. Modern authorities tell us that a zonal distribution of winds such as is shown in Fig. 31 implies pressure decreasing continuously one way round the circles of latitude. The Ferrel diagram leads to a *reductio ad absurdum*, a point which so far seems to be ignored by most writers of text-books. However useful " ideal " continents and oceans may be in fixing certain principles in the mind, they are not independent theoretically predicted schemes and the agreement between " theory " and observation is small matter for wonder.

Another ancient generalisation which has in recent years been proved wrong is the " rule " that the western equatorial sectors of the oceans are the homes of tropical revolving storms. Since the opening of the Panama canal brought about the frequenting of new trade routes, it has been found that the eastern north Pacific is also a region subject to such storms. As Mr. Kendrew has given us what is in most respects an excellent book, one may take it that in due course a second edition will be reached, when opportunity might be taken to bring in more recent views on the general circulation of the atmosphere.

In a work containing so many facts it is easy for occasional slips to occur. Some minor points to which attention should be given are the following: the west African type of tornado is characteristic of west Africa, not of the whole equatorial belt (p. 87); all dust is not hygroscopic nuclei, ions act as condensation nuclei only in exceptional circumstances (p. 126); glazed frost may also occur when a warm moist air current sets in suddenly after severe frost (p. 169 and p. 213); the statement that strato-cumulus is a combination of stratus and cumulus should be amplified (p. 175); "Millikan rays" is no longer used as a term for the penetrating radiation as Millikan was not the discoverer (p. 191); dust devils differ from tornadoes not only in intensity but in having an indifferent sense of rotation, the tornado of the eastern United States has always counter-clockwise rotation (p. 275). An interesting point about the Berg winds of the South African coast (p. 301) is that they often bring it about that the maximum temperature of what is nominally a winter day is 15° to 25° higher than that of summer. One mentions such minor points because Mr. Kendrew's previous work leads us to expect the highest standard from him, and their mention must not be taken as detracting from the general excellence of a book which can be strongly recommended as an introduction to the principles of weather and climate.

S. T. A. MIRRLEES.

The Gulf Stream and its problems. By H. A. Marmer. Reprinted from Smiths. Ann. Rep. for 1929, Washington, D.C., pp. 285-307.

This is a useful summary of existing knowledge of the oceanography of the Gulf Stream and its influence on the weather of the surrounding coasts. In the latter connexion, however, no reference is made to the English studies of the relations between the fluctuations of the Gulf Stream and European weather, described in several publications of the Meteorological Office.

Books Received

Average annual rainfall in New Zealand for the period 1891-1925. By E. Kidson, D.Sc., F.Inst.P. Giving maps showing average number of rain days per annum and mean annual rainfall for the period 1891-1925 for North Island and South Island separately.

Anales del Observatorio Nacional de San Bartolemé en los Andes Colombianos. Observaciones meteorologicas de 1928. Bogotá, 1930.

Royal Alfred Observatory, Mauritius. Annual report, 1929, and Results of magnetical and meteorological observations for January to December, 1928, January to December, 1929, and January to August, 1930; Port Louis, 1928, 1929 and 1930.

Beitrag zur Erklärung des "Barometereffektes" der Ultrastrahlung. By C. Dorno. Reprinted from Gerlands Beiträge zur Geophysik 26, 1930, pp. 395-402.

Obituary

M. Raoul Gautier.—The death has occurred of M. Raoul Gautier at Geneva on April 19th, 1931, in his 78th year. M. Gautier was born on April 15th, 1854, and devoted most of his life to the study of the climatology of Geneva and the neighbourhood, including the Great St. Bernard and St. Maurice. He was an honorary Professor, and at one time Rector of the University of Geneva and had been honorary Director of the Observatory at Geneva since 1889. He was Vice-President of the Geodesy section of the International Union of Geodesy and Geophysics and President of the Swiss Committee of Geodesy and Geophysics and of the Swiss Geodetic and Meteorological Commissions.

News in Brief

On the morning of March 4th a peculiar type of precipitation continuing for some hours was observed by Mr. R. T. Andrews at Larkhill, Salisbury Plain. The precipitation consisted of small irregularly shaped fragments of perfectly clear ice and did not resemble hailstones in any way. The sky was covered with nimbus and alto-stratus.

The General Board of the University of Cambridge has appointed Dr. H. Jeffreys, at St. John's College, reader in geophysics.

The Weather of April, 1931

Pressure was above normal over Spitsbergen, northern Scandinavia, Russia, Poland, the western Mediterranean and adjacent coasts, most of the North Atlantic, and the eastern and south-western United States, the greatest excesses being 6·9mb. at Waigatsch and 3·6mb. at Lat. 40° N., Long. 40° W. Pressure was below normal over Iceland, most of western Europe, Madeira, Florida, north-western United States and Canada, the greatest deficits being 5·7mb. at Seydisfjord and 4·6mb. at Juneau (Alaska). Temperature was above normal at Spitsbergen and northern Scandinavia, being as much as 16·1°F. above normal at Spitsbergen, and below normal over most of the rest of western and central Europe. Rainfall was deficient generally over western Europe with the exception of the British Isles and most of Sweden, where in Dalecarlia and Ostrogothia rainfall was twice the normal.

Over the British Isles the weather of April was mainly dull and unsettled with low day temperatures except between the 9th and 13th. In eastern England the rainfall was more than twice the normal in many places. A depression centred off the south-west coasts on the 1st moved slowly eastwards, causing heavy rain with local flooding in parts of Ireland and south-west England on the 1st, 2·00in. fell at Kilmacthomas, Co. Waterford, and rain in England and southern Scotland on the 2nd and in south-east England on the 3rd (Good Friday). Snow fell in parts of Ireland on the 1st and in Scotland on the 2nd. This was followed by an anticyclone giving fine sunny weather in Scotland on Good Friday and in southern England on the 4th, but this improvement was only temporary in the south and in Ireland, cool unsettled conditions prevailing there until about the 7th, while in Scotland and northern and eastern England the weather was fine and often sunny but cool; 12 hrs. bright sunshine were recorded at Durham and Kilmarnock on the 5th. On the 7th a depression stretching from Greenland to the Azores was approaching, the winds became southerly and there was a welcome change to warm conditions, a fine hot spell being recorded from the 9th to 13th. Temperature on the 11th rose to 68°F. at Cambridge and to 66°F. locally even as far north as Nottingham and Hull. The 11th and 13th were the sunniest days of the month with over 11 hrs. and 12 hrs. respectively at many places mainly in southern England; 13·0 hrs. were registered at Rhayader on the 13th. By the evening of the 13th the anticyclone over the southern British Isles was moving away westwards, and there was a decided drop in temperature accompanied by much cloud. From the 15th-19th a low-pressure system passed south-eastwards across the country and cold inclement weather prevailed. Maximum temperatures did not exceed 40°F. at Durham and Harrogate on the 18th. Snow, sleet or hail occurred at most places on the 17th, 18th and 19th, sleet and hail being reported even as far south as Guernsey on the 18th. Thunderstorms also were experienced locally in the eastern half of England on the 17th, 19th, 22nd and at Durham on the 24th. Precipitation though frequent during this period was usually slight in amount except in the south-east on the 19th, when 1·00in. was measured at Campsea Ashe (Suffolk). By the 18th the western part of the kingdom was coming under the influence of the anticyclone over the Atlantic, and sunny conditions prevailed in Ireland and west Scotland on the 18th, 19th and 20th. From then until the 30th depressions moved eastwards or south-eastwards across the country, and the weather became slightly milder but continued unsettled though with bright periods. Heavy rain occurred in England and Wales on the 24th and 25th, 2·06in. at Roe Wen (Carnarvon) on the 25th, and 1·91in. at Lincomb Lock (Worcester) on the 24th and sleet in Scotland on the 27th. Good sunshine records were obtained in Wales, north-west England and south Scotland on the 29th and over the country generally on the 30th; 13·6 hrs. were measured at Morecambe on the 29th. The distribution of bright sunshine for the month was as follow :—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	133	— 21	Liverpool	113	—45
Aberdeen	107	— 51	Ross-on-Wye	97	—53
Dublin	127	— 38	Falmouth	112	—72
Birr Castle	117	— 37	Gorleston	122	—62
Valentia	134	— 26	Kew	113	—44

The special message from Brazil states that the rainfall in the northern and central districts was scarce, with 0·47in. and 1·10in. below normal respectively, and abundant in the south with 1·34in. above normal. Five anticyclones passed across the country and there were frequent depressions in the south. The weather was generally fair and the crops in good condition. At Rio de Janeiro pressure was 0·2mb. below normal and temperature 0·5°F. above normal.

Miscellaneous notes on weather abroad culled from various sources. A spell of cold weather accompanied by snow occurred in northern France about the 20th, and heavy snowstorms were experienced in the neighbourhood of Grenoble about the same time. The late thaw in Russia delayed spring sowing for two or three weeks; by the 25th Vilna was seriously affected by floods as the river Vilia had risen 17ft. above its normal level, and several lives were lost in the floods in the Dvina Basin between the 25th and 30th. Navigation re-opened at Helsingsfors on the 3rd and at Hernosänd on the 29th. (*The Times*, April 6th-May 2nd.)

In a severe storm about the 10th, 125 fishermen were drowned off the south-west coast of Korea. Eleven people were killed at Taipo, near Hong Kong on the 20th in a railway accident due to the line being undermined by heavy rain; 13in. of rain fell in two days. (*The Times*, April 11th and 23rd.)

Abundant beneficial rains were experienced in South Australia at the beginning of the month. (*The Times*, April 4th.)

While Montreal lay under a heat wave on the 13th, an inch of snow fell in other parts of the Province of Quebec, followed later in the day by heavy rain. (*The Times*, April 16th.) Temperature was above normal over most of the United States during the middle of the month and rainfall generally below normal. Precipitation was below normal in the Argentine during the first part of the month. (*Washington, D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin.*)

Rainfall, April, 1931—General Distribution

England and Wales ...	173	per cent of the average 1881-1915.
Scotland	106	
Ireland	111	
British Isles	143	

Rainfall: April, 1931: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent. of Av.
Lond .	Camden Square	3·71	241	*Rut* .	Ridlington	3·74	238
Sur .	Reigate, Alvington	5·02	300	*Linc* .	Boston, Skirbeck	2·57	190
Kent .	Tenterden, Ashenden	3·00	185	,, .	Cranwell Aerodrome	2·93	222
,, .	Folkestone, Boro. San.	3·14	...	,, .	Skegness, Marine Gdns	2·23	166
,, .	Margate, Cliftonville	2·30	170	,, .	Louth, Westgate	2·92	175
,, .	Sevenoaks, Speldhurst	4·41	...	,, .	Brigg, Wrawby St.	3·17	...
Sus .	Patching Farm	3·21	183	*Notts* .	Worksop, Hodsock	3·35	228
,, .	Brighton, Old Steyne	2·55	157	*Derby* .	Derby, L. M. & S. Rly.	3·62	222
,, .	Heathfield, Barklye	3·84	208	,, .	Buxton, Devon Hos.	5·50	187
Hants .	Ventnor, Roy. Nat. Hos.	3·24	193	*Ches* .	Runcorn, Weston Pt.	2·41	139
,, .	Fordingbridge, Oaklnds	2·45	134	,, .	Nantwich, Dorfold Hall	3·12	...
,, .	Ovington Rectory	4·14	219	*Lancs* .	Manchester, Whit. Pk.	3·29	171
,, .	Sherborne St. John	3·05	172	,, .	Stonyhurst College	3·38	125
Berks .	Wellington College	3·24	201	,, .	Southport, Hesketh Pk	2·47	134
,, .	Newbury, Greenham	2·63	144	,, .	Lancaster, Strathspey	1·96	...
Herts .	Welwyn Garden City	3·73	...	*Yorks* .	Wath-upon-Dearne	2·89	183
Bucks .	H. Wycombe, Flackwell	3·12	...	,, .	Bradford, Lister Pk.	3·60	179
Oxf .	Oxford, Mag. College	2·93	190	,, .	Oughtershaw Hall	4·62	...
Nor .	Pitsford, Sedgebrook	3·85	252	,, .	Wetherby, Ribston H.	3·19	181
,, .	Oundle	2·34	...	,, .	Hull, Pearson Park	3·11	199
Beds .	Woburn, Crawley Mill	3·55	237	,, .	Holme-on-Spalding	3·34	...
Cam .	Cambridge, Bot. Gdns.	...	...	,, .	West Witton, Ivy Ho.	3·54	165
Essex .	Chelmsford, County Lab	3·26	255	,, .	Felixkirk, Mt. St. John	4·25	254
,, .	Lexden Hill House	2·80	...	,, .	Pickering, Hungate	3·98	238
Suff .	Hawkedon Rectory	4·46	290	,, .	Scarborough	3·12	200
,, .	Haughley House	2·62	...	,, .	Middlesbrough	2·87	209
Norf .	Norwich, Eaton	3·47	203	,, .	Baldersdale, Hury Res.	...	...
,, .	Wells, Holkham Hall	2·86	...	*Durh* .	Ushaw College	3·21	170
,, .	Little Dunham	4·28	264	*Nor* .	Newcastle, Town Moor	2·62	161
Wilts .	Devizes, Highclere	2·82	148	,, .	Bellingham, Highgreen	3·79	175
,, .	Bishops Cannings	2·97	147	,, .	Lilburn Tower Gdns.	3·17	160
Dor .	Evershot, Melbury Ho.	2·84	120	*Cumb* .	Geltsdale	2·56	...
,, .	Creech Grange	1·92	89	,, .	Carlisle, Scaleby Hall	2·21	113
,, .	Shaftesbury, Abbey Ho.	2·83	133	,, .	Borrowdale, Seathwaite	5·90	80
Devon .	Plymouth, The Hoe	2·84	125	,, .	Borrowdale, Rosthwaite	4·56	...
,, .	Polapit Tamar	2·80	120	,, .	Keswick, High Hill	2·57	...
,, .	Ashburton, Druid Ho.	..	...	*West* .	Appleby, Castle Bank	2·67	137
,, .	Cullompton	3·30	145	*Glam* .	Cardiff, Ely P. Stn.	2·97	117
,, .	Sidmouth, Sidmount	3·38	159	,, .	Treherbert, Tynywaun	6·27	...
,, .	Filleigh, Castle Hill	4·36	...	*Carm* .	Carmarthen Friary	3·73	136
,, .	Barnstable. N. Dev. Ath.	3·27	154	,, .	Llanwrda	3·82	116
Corn .	Redruth, Trewirgie	2·37	82	*Pemb* .	Haverfordwest, School	2·55	96
,, .	Penzance, Morrab Gdn.	1·67	69	*Card* .	Aberystwyth	3·74	...
,, .	St. Austell, Trevarna	3·30	117	,, .	Cardigan, County Sch.	3·19	...
Soms .	Chewton Mendip	2·66	90	*Brec* .	Crickhowell, Talymaes	...	...
,, .	Long Ashton	2·72	125	*Rad* .	Birm W. W. Tyrmynydd	5·09	138
,, .	Street, Millfield	2·25	113	*Mont* .	Lake Vyrnwy	5·54	184
Glos. .	Cirencester, Gwynfa	2·69	144	*Denb* .	Llangynhafal	3·84	202
Here .	Ross, Birchlea	2·91	153	*Mer* .	Dolgelly, Bryntirion	7·38	202
,, .	Ledbury, Underdown	3·28	180	*Carn* .	Llandudno	2·88	159
Salop .	Church Stretton	3·50	162	,, .	Snowdon, L. Llydaw 9	13·65	...
,, .	Shifnal, Hatton Grange	4·52	269	*Ang* .	Holyhead, Salt Island	1·85	89
Worc .	Ombersley, Holt Lock	3·37	222	,, .	Lligwy	3·10	154
,, .	Blockley	4·11	...	*Isle of Man*			
War .	Birminghm, Edgbaston	4·02	231		Douglas, Boro' Cem.	1·85	76
Leics .	Thornton Reservoir	4·60	271	*Guernsey*			
,, .	Belvoir Castle	3·31	216		St. PeterP't. GrangeRd.	2·07	103

Rainfall: April, 1931: Scotland and Ireland

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per cent. of Av.
Wigt	Pt. William, Monreith	1·92	87	*Suth*	Loch More, Achfary	7·07	146
,,	New Luce School	2·56	96	*Caith*	Wick	1·82	91
Kirk	Carsphairn, Shiel	3·53	85	*Ork*	Pomona, Deerness	2·38	115
Dumf.	Dumfries, Crichton, R.I	1·73	...	*Shet*	Lerwick	3·09	136
,,	Eskdalemuir Obs.	3·14	92	*Cork*	Caheragh Rectory	1·90	...
Roxb	Branxholm	2·63	139	,,	Dunmanway Rectory	2·31	56
Selk	Ettrick Manse	4·49	128	,,	Ballinacurra	2·18	84
Peeb	West Linton	2·71	...	,,	Glanmire, Lota Lo.	2·73	97
Berk	Marchmont House	3·19	158	*Kerry*	Valentia Obsy.	2·63	72
Hadd	North Berwick Res.	1·62	116	,,	Gearahameen	3·80	...
Midl	Edinburgh, Roy. Obs.	2·02	146	,,	Killarney Asylum	...	...
Lan	Auchtyfardle	1·94	...	,,	Darrynane Abbey	1·81	53
Ayr	Kilmarnock, Agric. C.	1·87	91	*Wat*	Waterford, Brook Lo.	2·36	93
,,	Girvan, Pinmore	2·22	75	*Tip*	Nenagh, Cas. Lough	2·76	110
Renf	Glasgow, Queen's Pk.	1·36	69	,,	Roscrea, Timoney Park	2·75	...
,,	Greenock, Prospect H.	2·32	64	,,	Cashel, Ballinamona	...	...
Bute	Rothesay, Ardencraig.	2·81	94	*Lim*	Foynes, Coolnanes	2·88	118
,,	Dougarie Lodge	2·14	...	,,	Castleconnel Rec.	2·70	...
Arg	Ardgour House	5·08	...	*Clare*	Inagh, Mount Callan	3·00	...
,,	Manse of Glenorchy	3·93	...	,,	Broadford, Hurdlest'n.	2·72	...
,,	Oban	2·19	70	*Wexf.*	Gorey, Courtown Ho.	2·80	128
,,	Poltalloch	2·45	81	*Kilk*	Kilkenny Castle	1·73	79
,,	Inveraray Castle	4·11	89	*Wic*	Rathnew, Clonmannon	3·36	...
,,	Islay, Eallabus	2·80	97	*Carl*	Hacketstown Rectory	4·50	170
,,	Mull, Benmore	4·80	...	*Leix*	Blandsfort House	2·75	105
,,	Tiree	2·28	...	,,	Mountmellick	...	...
Kinr	Loch Leven Sluice	2·33	121	*Off'ly*	Birr Castle	3·03	141
Perth	Loch Dhu	4·10	86	*Kild'r.*	Monasterevin	2·32	...
,,	Balquhidder, Stronvar	2·68	...	*Dubl*	Dublin, FitzWm. Sq.	2·72	143
,,	Crieff, Strathearn Hyd.	2·39	109	,,	Balbriggan, Ardgillan.	1·97	99
,,	Blair Castle Gardens	1·54	73	*Me'th*	Beauparc, St. Cloud	2·99	...
Angus.	Kettins School.	2·16	130	,,	Kells, Headfort	3·71	148
,,	Dundee, E. Necropolis	2·13	125	*W.M*	Moate, Coolatore	2·85	...
,,	Pearsie House	...	...	,,	Mullingar, Belvedere	3·64	154
,,	Montrose, Sunnyside	2·22	122	*Long*	Castle Forbes Gdns.	3·20	134
Aber	Braemar, Bank	2·96	125	*Gal*	Ballynahinch Castle	3·67	104
,,	Logie Coldstone Sch.	2·58	128	,,	Galway, Grammar Sch.	1·83	...
,,	Aberdeen, King's Coll.	1·54	82	*Mayo*	Mallaranny	4·24	...
,,	Fyvie Castle	2·06	96	,,	Westport House	3·66	135
Moray.	Gordon Castle	1·92	110	,,	Delphi Lodge	5·83	101
,,	Grantown-on-Spey	2·27	115	*Sligo*	Markree Obsy	2·98	112
Nairn.	Nairn, Delnies	1·56	104	*Cav'n.*	Belturbet, Cloverhill	2·46	107
Inv	Kingussie, The Birches	1·73	...	*Ferm.*	Enniskillen, Portora	2·15	...
,,	Loch Quoich, Loan	5·61	...	*Arm*	Armagh Obsy	3·35	159
,,	Glenquoich	4·75	73	*Down.*	Fofanny Reservoir	7·52	...
,,	Inverness, Culduhtel R.	1·98	...	,,	Seaforde	3·03	116
,,	Arisaig, Faire-na-Squir	2·00	...	,,	Donaghadee, C. Stn.	1·88	93
,,	Fort William	3·11	...	,,	Banbridge, Milltown	2·94	...
,,	Skye, Dunvegan	3·68	..	*Antr*	Belfast, Cavehill Rd.	3·10	...
R & C.	Alness, Ardross Cas.	3·32	137	,,	Glenarm Castle	3·35	...
,,	Ullapool	3·42	111	,,	Ballymena, Harryville	2·99	113
,,	Torridon, Bendamph	...	...	*Lon*	Londonderry, Creggan	2·64	103
,,	Achnashellach	4·49	...	*Tyr*	Donaghmore	...	...
,,	Stornoway	3·35	...	,,	Omagh, Edenfel	3·19	121
Suth	Lairg	2·89	123	*D.n*	Malin Head	2·24	...
,,	Tongue	2·51	96	,,	Dunfanaghy	2·43	...
,,	Melvich	2·49	...	,,	Killybegs, Rockmount	3·41	95

Climatological Table for the British Empire, November, 1930.

STATIONS	PRESSURE		TEMPERATURE							Relative Humidity.	Mean Cloud Am'nt	PRECIPITATION			BRIGHT SUNSHINE	
	Mean of Day M.S.L.	Diff. from Normal	Absolute Max.	Absolute Min.	Mean Values Max.	Mean Values Min.	Mean Values ½ max. and min.	Mean Values Diff. from Normal	Mean Wet Bulb			Am'nt	Diff. from Normal	Days	Hours per day	Percentage of possible
	mb.	mb.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	%	0—10	in.	in.			
London, Kew Obsy.	1011·6	− 3·0	57	25	50·4	39·2	44·8	+ 0·8	41·4	88	6·6	3·85	+ 1·63	15	2·0	23
Gibraltar	1020·3	+ 2·3	78	48	69·7	55·5	62·6	+ 2·1	55·1	84	5·4	7·26	+ 0·87	7	..	..
Malta	1020·2	+ 3·7	74	49	67·9	58·2	63·1	− 0·8	58·2	79	3·7	1·53	− 2·04	7	8·2	80
St. Helena	1014·9	+ 1·0	66	55	62·6	56·4	59·5	− 0·6	57·2	96	10·0	1·16	− 0·52	12	..	..
Sierra Leone	1013·2	+ 2·3	88	69	86·8	73·1	79·9	− 1·3	76·8	80	5·1	2·68	− 2·44	10	..	..
Lagos, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Kaduna, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Zomba, Nyasaland	1009·0	+ 0·1	94	62	86·6	67·3	76·9	+ 1·3	..	63	5·8	1·53	− 3·55	5	..	..
Salisbury, Rhodesia	1009·0	+ 0·7	91	57	82·3	61·3	71·8	+ 1·1	64·0	63	5·0	2·23	− 1·47	8	..	..
Cape Town	1016·8	+ 1·0	92	48	76·5	56·6	66·5	+ 2·1	59·9	71	4·0	1·03	− 0·06	4	..	..
Johannesburg	1011·4	+ 0·8	86	49	78·1	56·2	67·1	+ 3·6	58·9	65	4·0	3·00	− 1·96	12	8·8	66
Mauritius	1017·2	+ 1·1	89	62	81·9	68·4	75·1	− 0·4	70·3	65	6·9	2·11	+ 0·53	18	7·8	60
Bloemfontein	..	..	..	..	..	..	..	..	..	..	..	0·40	− 1·87	..	..	..
Calcutta, Alipore Obsy.	1014·1	+ 0·8	90	60	82·0	66·0	74·0	+ 0·9	66·1	83	4·9	2·43	+ 1·77	3*	..	..
Bombay	1012·4	+ 0·4	93	69	89·1	72·8	80·9	+ 0·4	70·7	74	2·2	0·00	− 0·45	0*	..	..
Madras	1011·0	− 0·3	89	65	82·5	71·8	77·1	− 1·8	73·7	85	7·1	21·45	+ 7·20	15*	..	..
Colombo, Ceylon	1011·6	+ 1·5	90	72	85·5	74·4	79·9	+ 0·2	76·2	79	7·7	9·73	− 2·06	21	6·8	58
Hongkong	1019·4	+ 1·8	86	61	75·7	66·7	71·2	+ 1·6	64·1	65	5·0	0·03	− 1·64	1	6·8	62
Sandakan	..	..	90	71	87·4	74·6	81·0	+ 0·2	77·7	83	..	16·77	+ 2·11	21	..	..
Sydney, N.S.W.	1014·3	+ 0·6	91	53	75·8	60·8	68·3	+ 1·2	62·3	58	5·9	0·68	− 2·13	9	8·1	58
Melbourne	1014·3	+ 0·1	89	44	73·0	51·5	62·3	+ 1·0	54·6	57	6·7	2·35	+ 0·13	13	6·5	46
Adelaide	1016·2	+ 1·1	97	44	77·8	56·5	67·1	+ 0·2	56·7	43	5·4	0·92	− 0·24	11	8·9	64
Perth, W. Australia	1017·3	+ 2·0	97	47	76·6	57·6	67·1	+ 1·1	59·1	52	4·8	0·97	+ 0·18	9	9·5	69
Coolgardie	1015·2	+ 2·1	99	46	86·7	55·3	71·0	+ 0·2	56·2	33	2·8	0·03	− 0·65	1	..	..
Brisbane	1016·3	+ 1·8	97	59	83·7	65·2	74·5	+ 0·9	66·5	55	3·1	0·95	− 2·71	8	9·1	68
Hobart, Tasmania	1008·7	− 0·7	80	39	65·1	47·5	56·3	− 0·9	49·5	54	7·1	2·52	0·00	17	7·4	51
Wellington, N.Z.	1008·8	− 3·3	65	39	59·0	46·7	52·9	− 4·0	49·9	71	7·4	4·02	+ 0·50	11	6·6	46
Suva, Fiji	1012·1	+ 1·0	87	66	81·7	72·1	76·9	− 0·3	72·0	75	8·4	8·13	− 1·38	19	3·7	29
Apia, Samoa	1010·0	+ 0·5	89	74	85·2	76·5	80·9	+ 2·2	78·5	81	5·6	11·75	+ 2·46	20	5·9	46
Kingston, Jamaica	1012·9	+ 0·5	91	67	87·3	71·6	79·5	+ 0·2	70·5	87	5·3	3·55	+ 0·52	8	..	..
Grenada, W.I.	1013·9	+ 2·9	90	71	87·5	74·0	80·7	+ 1·4	74·1	77	4·6	5·08	− 3·31	17	..	..
Toronto	1019·7	+ 2·9	61	13	46·7	34·9	40·8	+ 4·5	35·7	81	7·1	0·68	− 2·27	10	3·0	31
Winnipeg	1016·1	− 0·6	58	14	33·1	17·9	25·5	+ 4·7	..	..	5·7	1·55	+ 0·59	9	3·8	42
St. John, N.B.	1020·0	+ 6·1	54	10	45·7	30·9	38·3	+ 1·6	33·8	79	6·0	2·17	− 2·24	6	4·1	43
Victoria, B.C.	1019·8	+ 4·3	56	31	47·6	40·5	44·1	− 0·3	42·0	91	8·3	1·31	− 5·15	13	2·5	27

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.