M.O. 225 i.

METEOROLOGICAL OFFICE.

THE WEATHER MAP.

(Fourth Issue.)

AN INTRODUCTION TO MODERN METEOROLOGY.

BY

Sir NAPIER SHAW, F.R.S.,

Director of the Meteorological Office.

Published by the Authority of the Meteorological Committee.

LONDON:
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BY DARLING AND SON, LIMITED, BACON STREET, E. 2.
And to be purchased from
The Meteorological Office, Exhibition Road, London, S.W. 7.

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William M Burnett F.C.

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*** Words printed in capitals in the text are to be explained in the Meteorological Glossary (M.O. 225 ii.).

THE WEATHER MAP.

AN INTRODUCTION TO MODERN METEOROLOGY.

METEOROLOGY AND MILITARY OPERATIONS.

The reason why those who are concerned in warlike operations wish to know something of modern METEOROLOGY is that the weather is one of the elements of success in the conduct of the operations whether they are on sea or land or in the air. The weather is, indeed, a consideration in nearly all human occupations, not less in warlike operations than in others.

When the weather is the only obstacle to success it may be possible by suitable precautions to get the better of it. A large part of the energy and enterprise of civilisation has been devoted to making the ordinary course of life independent of the weather. The dweller in a large city is enabled by the arts of the builder and engineer, by the makers of clothes, and by the organisation of the means of locomotion, to live in comfort and to carry on his business whatever the weather may be. Occasionally a snowstorm or a thunderstorm or a long drought may overpower the precautions that have been taken, but in our climate that seldom happens. And so far as locomotion is concerned, if the weather is the only enemy to be considered, it may be possible, for example, to improve the construction of aircraft so that a pilot may go out in all weathers and reach his objective without serious misadventure; and, at the worst, the journey can be postponed and the pilot can take shelter till the weather improves. But when other considerations enter into the question, and it becomes a matter of working not

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only against the weather but against time, as in the case of provisioning cities or large bodies of men or in the case of a steamer of the mercantile marine, where time is money, or in that of a farmer whose crops are lost if favourable opportunities are missed, or if it be against some other enemy as in military operations, when it is often a question of now or never, or indeed whenever it is a matter of competition, rivalry or antagonism, the influence of favourable or unfavourable weather is far too great to be disregarded.

It is needless to give an historical account of the influence of weather in war; the following episode in a Syrian Campaign will suffice.

> "Now they that were in the tower sent messengers unto Tryphon to the end that he should hasten his coming unto them by the wilderness, and send them victuals.
>
> "Wherefore Tryphon made ready all his horsemen to come that night; but there fell a very great snow, by reason whereof he came not."

An expedition that is just within the range of an airman's powers with a favourable wind is outside the range if the wind and its changes turn out to be adverse. By working with a liberal factor of safety and by limiting the scope of operations according to the range for the most unfavourable conditions, we may secure safety but fail to command success; whereas to take advantage of the variation of wind at different levels, or of a spell of fine weather long enough for the enterprise in hand but not longer is worth trying for. Nor is the airman in the air the only consideration. A good deal of damage may be done to his belongings on land while he is in the air.

It is easy to say that, in spite of the progress of meteorology within the last sixty years, we are still unable to predict the weather with actual certainty, and that as you cannot be certain it is just as well not to think about it at all. But although our knowledge is imperfect it is not therefore advisable to disregard what we know. It comes to this: that, in spite of the remaining uncertainty, of two sides which are otherwise equally balanced, the one that is more skilful in making use of a knowledge of the weather has the better prospect of winning in any operations in which they are opposed.

WEATHER RECORDS AND CLIMATE.

There is, as a matter of fact, a great deal of information about the weather which is not dependent on prediction and which is still emphatically useful. For example, the organised study of weather over the sea enables a seaman to know, simply from the recorded experience of others, what kind of weather may be expected in any particular locality, what is the greatest heat or the greatest cold, the nature of the PREVAILING WINDS, the FREQUENCY of fog, the frequency of rainfall and of snowfall, and so on. All these things can be obtained simply by organising the recorded experience of others. And a similar statement is true for those who are responsible for military operations of all kinds. What is the extent of the cold of winter or the heat of summer against which precautions must be taken in the interest of the men or their engines? At what times of the year will the roads be dry either from being frozen or from dry weather? What are the prevailing winds? and so on. These are the matters which are summed up in a statement of CLIMATE. To neglect the experience of the past in such matters is hardly permissible and is, in fact, never really contemplated by any responsible person. But even responsible persons are apt to think that the recollections of their own experience in situations which they think are similar are a sufficient guide. That is, unfortunately, not always good enough in modern conditions, when particulars of the climate of any locality can generally be had for the asking. In all such matters a written record on an organised plan is much better than the most voluminous personal recollections.

It may easily be admitted that the anticipation of the anomalies of the weather of the coming day, the coming week or the coming season is the most attractive of all the departments of weather-study, but let us not, on that account, fall into the common error of supposing that it is the only one. For the floating of an airship, the conditions of soaring of an aeroplane, the working of a petrol-engine, we are more dependent upon the normal atmospheric conditions at various heights above the ground than upon their temporary anomalies. So also in regard to the provision for transport and supply, the maintenance of the health of troops and the care of sick and wounded, the regularities of climate have to be reckoned with, as well as the vicissitudes of weather; outside the British Isles they are often the more imperious factor.

The first business, therefore, of the military meteorologist is to put together in the most telling form all the available records of TEMPERATURE, WIND and WEATHER for the neighbourhood of the operations. With a little practice one finds that a map is the best form in which to give the information and the month is a convenient division of the year for the purpose. The first exercise in meteorology is to read a monthly meteorological summary. A Climatic summary for a station in each of the principal regions of military operations and some diagrams representing summaries of pressure, wind, temperature, humidity, and rainfall at the British observatories are given in a Climatological Supplement to this introduction. (Pages 55 to 103.)

THE NECESSITY FOR FORECASTS OF WEATHER.

But CLIMATOLOGICAL information is only preliminary; the anticipation of weather to come remains an imperative necessity. Always it has been so. No one can undertake military operations on sea or land or in the air without forming the best idea possible to him of what the weather is going to be. The monthly climatic chart will tell him what it may be but not what it will be. Even if he decides to ask no opinion but chance it, he only means that in his own opinion the probability of really prohibitive weather is so small that it may be disregarded. It is quite unusual to find anyone who is willing simply to chance it. Very few persons are content to act upon their own opinion about coming changes of weather. If the weather happens to be favourable when the decision has to be taken they may assume that it will go on being so; if not, as from time immemorial, they will appeal to all sorts of signs in the sky, or in the behaviour of birds, or to the opinion of some weatherwise person, who is personified in meteorological history as the "SHEPHERD OF BANBURY."

The WEATHER MAXIMS for sailors which one finds in handbooks on navigation are very good examples of the results of experience; in an emergency anything must be clutched at to help towards a decision one way or the other. Forecast of some sort everyone must have. It is desirable to have the best that can be got, and according to the experience of all civilised nations the best is to be obtained by FORECASTS based upon the methods developed by modern meteorology.

Modern Meteorology the Work of an Organisation, not of an Individual.

It is necessary to point out that modern meteorology means a meteorological organisation, not merely an individual meteorological expert. The making of a single forecast in any one of the meteorological offices of Europe, America, Australia or the Far East requires the organised co-operation of some hundreds of persons; about a hundred observers who note the necessary observations simultaneously at as many separate places and hand in their reports to the telegraphists who transmit them to one centre where the meteorological expert charts them on a map and draws therefrom the conclusions on which the forecasts are based.

The Meteorologist at Head Quarters.

The preparation of the map is an essential part of the process. No meteorologist in the modern sense attempts to forecast the weather without reference to a map prepared either by himself or by some one with whom he is in direct communication, from observations transmitted by telegraph for the purpose. No amount of weather-wisdom or weather-lore or experience is a substitute for the map. The more expert and accomplished the meteorologist the more certain he is that all he can do without the materials for constructing a map, though he may have a barometer and other instruments at hand, is to make a guess at what the map is like and think out from that what the weather changes are likely to be.

With sufficient intelligence and sufficient experience he may be able in that way to make useful suggestions, but they are not forecasts in the modern sense.

It is a common experience of professional meteorologists away from their base to find themselves appealed to for an opinion about the weather, judging from the signs of the sky alone, because they are learned in such things. That is exactly what they are not. Accustomed to refer everything to a map, without one they feel themselves to be rather worse off than those are who are unaccustomed to its use.

Consequently, in making provision for expert meteorological assistance in the conduct of military operations it is not enough to have an expert meteorologist on the spot; he must have the material for making a weather map or have access to the organisation which makes one day by day and indicates to him the conclusions to be drawn from it, which can only be transmitted in technical language, and are therefore not necessarily understood by those who are unfamiliar with scientific terms.

A modern meteorologist thinks in maps; his language and modes of expression are formed thereby. An explanation of the method of forecasting by means of maps is therefore offered here.

A Map of the Weather.

Modern meteorology is essentially dependent upon the modern means of communication, the electric telegraph, the telephone or wireless telegraphy. The electric telegraph was practically a creation of the second quarter of the nineteenth century and as an organised means of communication reached its full development with the laying of the Atlantic Cable in 1866. Thereafter its history deals simply with extensions and improvements. The weather map had been brought within the range of possibility. On September 3rd, 1860, Admiral FitzRoy began the regular daily collection of reports of weather by telegraph for the Meteorological Department of the Board of Trade which was under his charge.

The reports which he received included readings of the BAROMETER and THERMOMETER and notes of WIND and WEATHER. Of the barometer, thermometer and wind there is more to be said presently. For the moment I wish to confine the reader's attention to the weather.

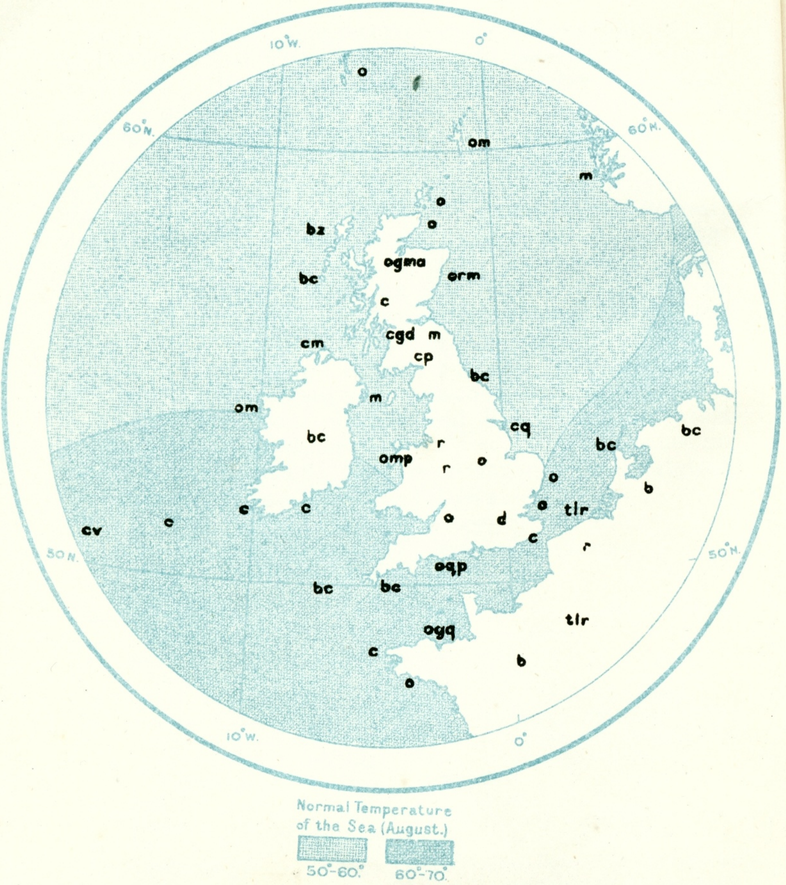
First, what does it include and how is it to be described? It includes the STATE OF THE SKY, whether it is clear, cloudy or overcast, the state of the air, whether it is clear, MISTY or FOGGY, whether RAIN, HAIL or SNOW is falling; and if so, whether it is steady rain, showers or drizzle; whether there is THUNDER or LIGHTNING; and, as reports are always sent in the early morning, to these we may add whether there is DEW or HOAR FROST.

To make the reports concise and for the sake of uniformity the observer learns to use a code of letters which was originally introduced by Admiral Sir Francis Beaufort for use at sea, but which is equally convenient for use on land. Some additions have been made to the original schedule and it now stands as follows:—

BEAUFORT NOTATION.

- b blue sky (not more than a quarter of the sky covered).
- bc sky partly cloudy (one half covered).
- c generally cloudy (three quarters covered).
- d drizzle, or fine rain.
- e wet air without rain falling; a copious deposit of water on trees, buildings or rigging.
- f fog.
- g gloom.
- h hail.
- l lightning.
- m mist.
- o overcast sky.
- p passing showers.
- q squalls.
- r rain.
- rs sleet, *i.e.*, rain and snow together.
- s snow.
- t thunder.
- u ugly, threatening sky.
- v unusual visibility. The horizon or distant hills unusually clear.
- w dew.
- x hoar frost.
- y dry air (less than 60 per cent. humidity).
- z dust haze; the turbid atmosphere of dry weather.

DISTRIBUTION OF WEATHER, 6 P M. 2nd AUGUST, 1915.



For the explanation of the letters *see* p. 10.

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These, with the wind and the vagaries of temperature, are the matters which affect everyone and which the science of meteorology has to account for and explain. In these matters the observer is simply the reporter of the local conditions; he is not required to offer any explanation of his own.

Let us now suppose that we have a corps of OBSERVERS at selected points which we call STATIONS distributed all over the country, who note the weather at an agreed hour and immediately telegraph their notes to headquarters. These results are plotted at once on a map. The result is that the staff at headquarters knows what the weather is, not only on the spot but at selected points over a large area, the British Isles, for example. The map is always instructive and sometimes astonishing. The weather may be quite fine over the greater part of the area, though it is very seldom that there is a map of the British Isles without rain shown somewhere on it. On the other hand there is hardly ever a map showing rain everywhere. Sometimes it is brilliantly fine in one region and yet it is raining, perhaps a thunderstorm, not far away. Here (*Plate I*) is an example of a map showing the distribution of weather at 6 p.m. on 2nd August, 1915.

The letters are entered in the immediate neighbourhood of the stations at which the weather is recorded. There is a thunderstorm at Paris and Flushing, rain along a line from Paris to Aberdeen through Liverpool and Glasgow; there is cloud generally except in middle France, Holland and at Stornoway.

For the purpose of mapping, it is more convenient to use symbols which identify more clearly the localities referred to instead of letters for the state of the sky, so we will give later the symbols used to represent the weather in the Daily Weather Report of the Meteorological Office and a copy of the map expressed in symbols (see *Plate V*).

The first impression that one gets from looking at such a map is that everybody who is interested in the weather, for business or pleasure, would like to be informed about it; and the next impression is that there must be some reason to account for the peculiarities of the distribution, some reason why it is fine in one place and raining in another, a hundred or five hundred miles away. It is the pursuit of the impulse, which naturally follows the second impression, that constitutes modern meteorology.

A Map of the Winds.

First of all let us bring the wind into account, because it is a matter of common knowledge that the weather often changes when the wind changes. That is easily done because the observer who notes the weather can also observe the wind and include the observations in his telegram. He may not have any special instrument for measuring the direction and force of the wind, but he can estimate the direction if he knows the points of the COMPASS and can see which way smoke is blowing, or some other common indication of the wind-motion. If necessary he must find out the points of the compass, and in that case he must recollect that the mariner's compass or MAGNETIC NEEDLE does not point exactly North but about 18 degrees to the west of it in these Islands. He can also estimate the force of the wind in accordance with a scale of numbers which we also owe to Admiral Beaufort and to which the indications have been assigned, as shown on p. 13.

Beaufort Number.	Specification. General.	Specification. At Sea.	Description of Wind for use on Land.
0	Calm	Calm ...	Calm ; smoke rises vertically.
1	Light air ...	Light breeze.	Direction of wind shown by smoke drift, but not by wind vanes.
2	Slight breeze...	Light breeze.	Wind felt on face; leaves rustle; ordinary vane moved by wind.
3	Gentle breeze...	Light breeze.	Leaves and small twigs in constant motion; wind extends light flag.
4	Moderate breeze.	Moderate breeze.	Raises dust and loose paper; small branches are moved.
5	Fresh breeze ...	Moderate breeze.	Small trees in leaf begin to sway; crested wavelets form on inland waters.
6	Strong breeze...	Strong wind.	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.
7	High Wind ...	Strong wind.	Whole trees in motion; inconvenience felt when walking against wind.
8	Gale	Gale forces.	Breaks twigs off trees; generally impedes progress.
9	Strong gale ...	Gale forces.	Slight structural damage occurs (chimney-pots and slates removed).
10	Whole gale ...	Storm forces.	Seldom experienced inland; trees uprooted; considerable structural damage occurs.
11	Storm	Storm forces.	Very rarely experienced; accompanied by widespread damage.
12	Hurricane ...	Hurricane ...	

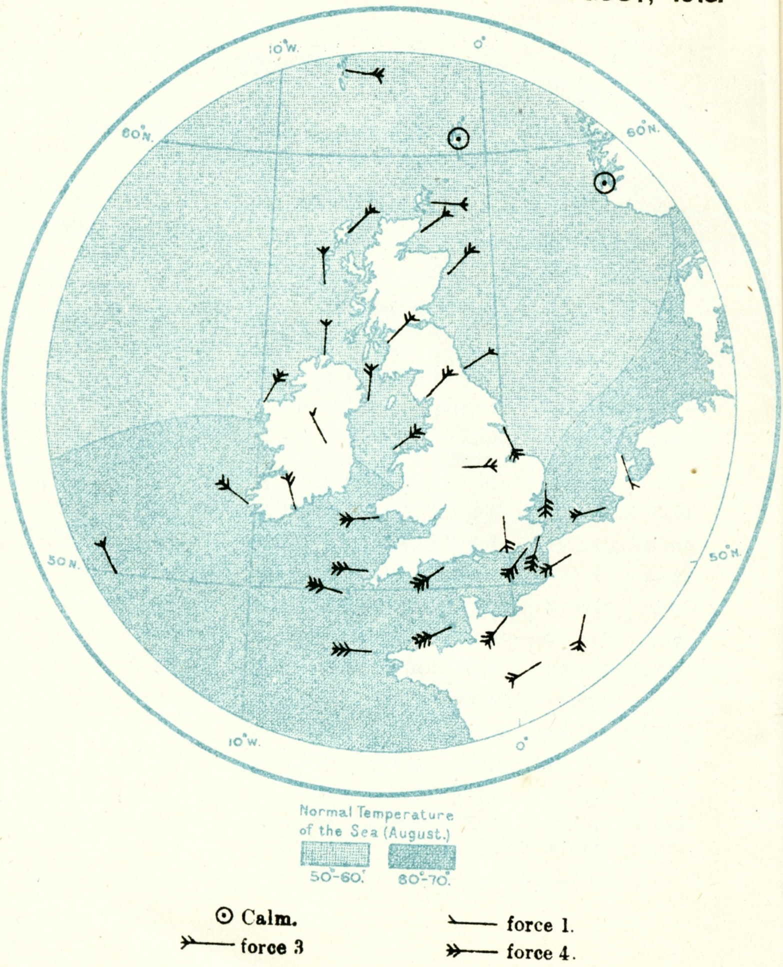
A table of equivalents is given overleaf.

The Beaufort Scale.

Table of Equivalents in Force and Velocity. (See Observer's Handbook.)

Pressure of Wind on a Plate		Equivalent velocity in miles per hour.	Beaufort Number.	Limits of Velocities.			
in lbs. per square foot.	in Millibars (10^3 dynes per $cm.^2$).			Statute Miles per Hour.	Nautical Miles per Hour.	Metres per Second.	Feet per Second.
0	0	0	0	Less than 1	Less than 1	Less than 0·3	Less than 2
·01	·01	2	1	1–3	1–3	0·3–1·5	2–5
·08	·04	5	2	4–7	4–6	1·6–3·3	6–11
·28	·13	10	3	8–12	7–10	3·4–5·4	12–18
·67	·32	15	4	13–18	11–16	5·5–8·0	19–27
1·31	·62	21	5	19–24	17–21	8·1–10·7	28–36
2·3	1·1	27	6	25–31	22–27	10·8–13·8	37–46
3·6	1·7	35	7	32–38	28–33	13·9–17·1	47–56
5·4	2·6	42	8	39–46	34–40	17·2–20·7	57–68
7·7	3·7	50	9	47–54	41–47	20·8–24·4	69–80
10·5	5·0	59	10	55–63	48–55	24·5–28·4	81–93
14·0	6·7	68	11	64–75	56–65	28·5–33·5	94–110
Above 17·0	Above 8·1	Above 75	12	Above 75	Above 65	33·6 or above.	Above 110

DISTRIBUTION OF WIND, 6 P.M. 2nd AUGUST, 1915.



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We can, therefore, now put on the map the indication of the wind at each one of our stations and then it becomes quite clear that the winds at neighbouring stations stand in some relation to each other (*Plate II*). The south-westerly winds group themselves in one region about the English Channel, north-easterly ones in another over Scotland, with intermediate winds between, southerly on the east, northerly on the west. It is quite unlikely that you will find a north-easterly wind in the middle of a region of south-westerly winds. It might possibly be so if the winds generally were merely light airs but not if they were winds of moderate strength. If such a case were found it would at once arouse curiosity as to how it could possibly occur. Wind maps, to a certain extent, confirm the ordinary impression that wind and weather go together, but with many exceptions. It often rains with a south-westerly wind but it is sometimes extraordinarily fine with the same wind. An easterly or north-easterly wind often brings us fine weather and yet our most PERSISTENT RAINS come with easterly or north-easterly winds. Why is this?

It is clear that we must be able to answer these questions, explaining what does happen before we can say what is going to happen in the future. In order to do this we must understand something of the nature and properties of the ATMOSPHERE, the gaseous envelope of our planet in which all these changes take place.

The Atmosphere.

The air which surrounds us and is carried along with the earth on which we live and which, regarded in its entirety, is called the atmosphere, is a mixture of gases, In the regions which are within our reach, up to 10 kilometres, 6 miles or 33,000 feet, the greater part of it is nitrogen, one of the chemical constituents of ammonia and also of nitric acid and the nitrates which are so important in gunpowder and nearly all other explosives. In the atmosphere, however, nitrogen is a peculiarly inert gas. It merely dilutes the more active gas oxygen, which forms about one-fifth of the atmosphere. Oxygen is one of the active substances in all forms of combustion. The burning of fires, and the slower processes which go on within the human body, are forms of combustion in which oxygen combines with substances like wood or coal or with the blood in the lungs. In the combination a proportionate quantity of heat is produced, and a corresponding amount of carbonic acid gas which mixes with the other gases of the atmosphere. Without oxygen no fire can be maintained and the chemical processes in the body necessary for life cannot go on. Thus the oxygen of the atmosphere is a very important element but in meteorology its special characteristics do not concern us. Combustion is constantly going on and oxygen is being used up, but there is a reverse process going on in growing plants. They act upon the carbonic acid gas in the air which surrounds them, take it into their structure and liberate oxygen. The result of these manifold chemical actions, with the mixing that is made by the winds, is to maintain the mixture of nitrogen and oxygen in the atmosphere practically unchanged.

Besides these two constituents there are small amounts of other gases, one the inert gas argon and the other carbonic acid gas, one of the products of the combustion of wood, coal, etc. These are also practically invariable in the open air, but there is also always in the open air some water-vapour which is very variable in its amount. The water-vapour passes into the atmosphere as an invisible gas by evaporation from all surfaces of water, even when it is frozen, as well as, to a less extent, from nearly all forms of combustion.

WATER-VAPOUR: EVAPORATION AND CONDENSATION.

Unlike the other constituents of the atmosphere WATER-VAPOUR is of the greatest importance in meteorology. It is the form in which the enormous quantities of water represented primarily by rain or snow, and secondarily by RIVERS, LAKES, ICEBERGS and GLACIERS, are transported from one part of the earth to another. All the water which falls as rain or snow in a year has been evaporated from the sea or other surfaces of water or ice, or from plants or wet soil and transported in the form of invisible water-vapour mixed with the other gaseous constituents of the atmosphere. By natural processes which can be imitated quite easily and effectively in a physical laboratory, part of the invisible water-vapour in the air can be reconverted to visible water in drops as in CLOUDS and rain, or as SNOW-CRYSTALS in certain kinds of cloud in the atmosphere itself, or on plants and buildings as dew or hoar-frost. The conversion of invisible vapour into visible drops or crystals is called CONDENSATION which is the counterpart of EVAPORATION.

Evaporation and condensation are related to changes of temperature in the air and the study of these changes belongs, therefore, to the science of heat which in modern times finds its most effective illustrations in the working of the steam-engine. The atmosphere may, therefore, be looked upon as a steam-engine of huge dimensions drawing its heat from the sun and ultimately sending it out again into space. At the end of a year so much heat has been taken by the earth from the sun, so much has been used up in the operations of running water and flowing air, so much sent out again into space. As after the lapse of centuries, so far as we can tell, the whole earth becomes neither warmer nor colder we must suppose that in the end the heat which has been taken in has been got rid of by RADIATION into space, but in the meantime the whole course of the wind and weather all over the world has been controlled and ordered by the process of warming and cooling, evaporation and condensation.

The weather which we experience in any particular locality is a small part of the great process going on in the whole atmosphere of which evaporation and condensation are the most striking incidents. Evaporation is included because if there were no evaporation condensation would soon come to an end; but evaporation is a silent invisible process, whereas condensation furnishes in the form of cloud, rain, snow, THUNDERSTORMS, the most impressive manifestations of the energy of nature.

From recent researches by means of balloons it appears that only the lowest layer of the atmosphere, the TROPOSPHERE, about 10 kilometres or 33,000 ft. thick, is concerned in the process of condensation and evaporation. That does not define the limit of the atmosphere itself. Observations of METEORS, AURORÆ and other phenomena indicate that the atmosphere is still recognisable at a height of some 80 or 100 miles. At the greatest heights the composition is probably quite different from what it is near the surface. From 57 kilometres upwards it is thought to be mainly hydrogen. But it is with the lowest 10 kilometres, the region of nitrogen, oxygen and water-vapour that meteorology is concerned.

Temperature and Humidity.

Our interest in the TEMPERATURE and PRESSURE of the atmosphere is however not so limited.

Temperature is indicated by the THERMOMETER and tells us how hot or how cold the weather is. It is a very important consideration because the human organism is so adjusted that without special precautions it can only bear a very limited range of temperature with comfort. 62½° Fahrenheit, 290 absolute, is the best temperature for an ordinary living room. A thinly clad person feels very cold unless he is actively employed, if the thermometer falls below 54° F., 285a.; and if it gets above 72° F., 295a., it feels very hot for hard work for those who are not used to it. The feeling of oppression is not simply a matter of temperature; it depends also on the dryness or moistness of the atmosphere.

Conversion table for Temperature.

a.	C.	F.
320	47°	116·6°
310	37°	98·6°
300	27°	80·6°
290	17°	62·6°
280	7°	44·6°
273	0°	32°
255·2	−17·8	0°
0	−273	−459·4°

A moist atmosphere is peculiarly disagreeable if the temperature is below 50° F. 283a. or above 70° F. 294a. These conditions can be determined by the WET BULB THERMOMETER. When the wet bulb is above 90° F. life is hardly supportable, and when the temperature is only a few degrees above the freezing point, very damp air is very objectionable Consequently considerations of health lead us to pay careful attention to the wet bulb as well as the dry bulb. HUMIDITY is the term which meteorologists use to describe the state of the atmosphere as regards dryness or moistness. When the air is dry the humidity is said to be low, and when it is damp the humidity is said to be high. The temperature, and still more the humidity, generally vary very considerably between day and night (DIURNAL VARIATION) and the temperature varies still more between SUMMER and WINTER (SEASONAL VARIATION), but the seasonal variation of humidity is relatively small. The great advantage of the British climate is that during the working hours of the day the temperature and humidity generally come within a workable range at any time of the year; when it is very hot in summer it is generally very dry, so that there are very few days in the year in which outdoor work has to be suspended on account of the heat or the cold. But anyone who is accustomed to the relative dryness of the eastern side soon feels the oppression of moist heat if he goes to the extreme western side of Ireland.

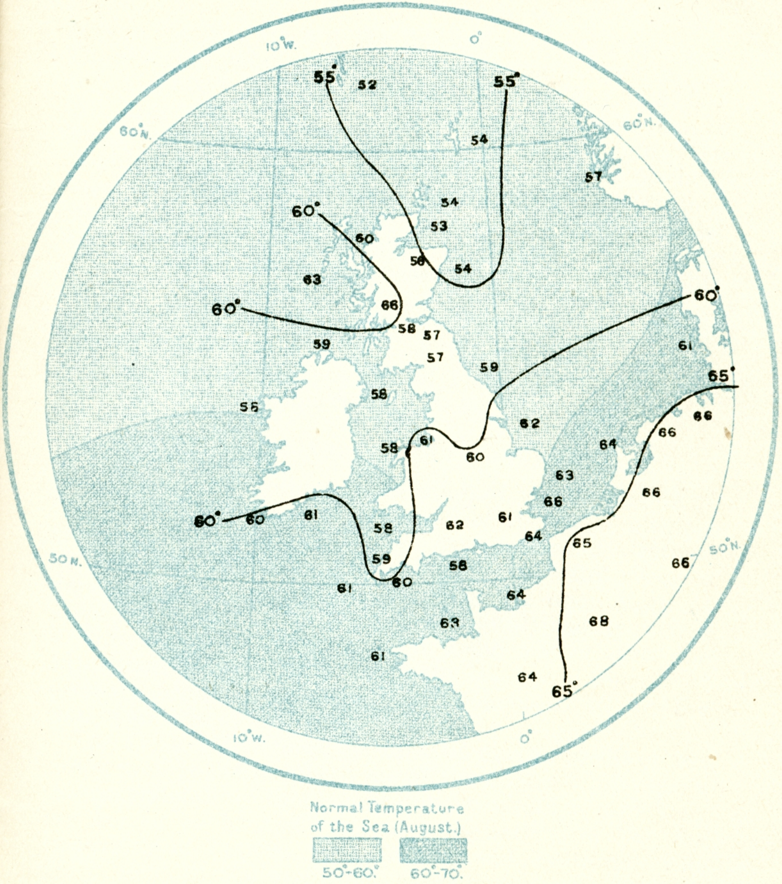
Plate III shows the distribution of temperature over the British Isles at 6 p.m. on the 2nd August, 1915.

Lines are drawn separating the figures above 65 from those below, those above 60 from those below, and the figures above 55 from those below. Some figures remain isolated.

For reasons which are now clearly understood, the temperature of the air generally gets lower as one ascends. The average fall of temperature near the surface is about 1° F. for each 300 feet, 10° F. for a kilometre. With a surface temperature of 50° F. we might anticipate* that the FREEZING POINT would be reached at 5,500 feet ($1\frac{3}{4}$ kilometres above the surface), or 1,000 feet above the top of Ben Nevis, 2,000 feet above the Welsh mountains. On mountain slopes temperature falls rather more than it

* For further information see *Glossary s.v.*, INVERSION.

DISTRIBUTION OF TEMPERATURE, 6 P.M. 2nd AUGUST, 1915.



The figures give the observed temperatures on the Fahrenheit scale.
The black lines are isotherms.

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does in the free air, but the difference is not important. The freezing point of water is the average temperature of July at 7,500 feet, 2·5 kilometres. At a height of 27,000 feet MERCURY freezes, and the seasonal variation then is much less. The fall of temperature goes on until the height of the highest mountains of the world is reached, about 30,000 feet, 10 kilometres, and then the temperature ceases to vary with further increase of height. So the variation of temperature with height stops where the water vapour in the air ceases to be an appreciable amount, see pp. 46, 47.

The coincidence of the effective height of the WATER-ATMOSPHERE and the tops of the highest mountains with the cessation of the fall of temperature is curious. There is, perhaps, some connexion between them.

PRESSURE AND ITS MEASUREMENT.

We now come to the consideration of the PRESSURE of the atmosphere, the most important of the meteorological elements, because all the rest of the features of weather, viz., wind, temperature, humidity, cloud, rain, seem to depend upon it, or rather, not so much upon itself as upon its changes. The winds are certainly closely related to differences of pressure, and in some way or other the adjustment of the flow of air to the requirements of pressure bring all the rest of the phenomena of weather into operation.

The ideas which form the basis of measurement of the pressure of the atmosphere are of the greatest importance in understanding the conditions of weather, but they are not to be formed without some experience of the behaviour of FLUIDS, both LIQUID and GASEOUS. The air is held to the earth, just as water is, by its WEIGHT.

The water only fails to cover the whole earth as the air does, because there is not enough of it. Both in air and water the weight of the upper layers influences the whole of the lower layers in a special way which is characteristic of fluid pressure. Everything immersed in it is pressed with a pressure that increases with the depth of immersion until the effect is absolutely crushing in actual fact. Everything that has hollow spaces must be crushed by pressure if it sinks deep enough in water. A similar statement is true of the atmosphere, only, with that, it is upwards where the pressure gets less and less that we think about, not so much downwards where it gets more and more.

The peculiarity of fluid pressure which we must carry with us is that of transmission. In ordinary domestic experience it is difference of LEVEL which decides which way water shall flow. "Water always finds its own level" is the proverbial way of putting it. It does not matter how little is the crevice through which the water has to creep. Give it time and it will settle itself just the same in the end as if the crevice were an open door. With air the same is true only less time is required to get the levels right, so that we come to the general principle that the pressure of still water or of the still atmosphere is always the same at the same level, inside a room or outside. In the most obscure recesses of an enclosed building there are always crevices enough to allow the pressure to be the same at the same level inside and out, except during such rapid changes of pressure as are produced by sudden GUSTS OF WIND and still more noticeably by the WAVES OF EXPLOSIONS.

So we regard atmospheric pressure as ubiquitous, the same everywhere at the same level, unless the air is moving. When it is moving we regard the motion as an incident in the equalising of the level. So it is, but in the free atmosphere the process of equalising is not the simple process of flowing through a door, it has laws of its own which we shall have to consider in due time.

With the ubiquity of pressure comes the idea of its measurement and for this purpose we regard the pressure as uniform over a square inch or square centimetre. One only loses the thousandth part of the pressure of the atmosphere by climbing up ten metres (33 feet) so that the variation over a few feet is not appreciable except with a delicate instrument. So if we take the pressure of the atmosphere as $14\frac{3}{4}$ lb. per square inch or a kilogramme per square centimetre, we soon see that the forces which we have to deal with when atmospheric pressure is concerned are enormous. A kilogramme per square centimetre gives a ton over 1000 square centimetres, about a square foot, and therefore nine tons to the square yard.

Thus the forces of atmospheric pressure are very great when the areas considered are large.

THE BAROMETER.

For measuring the pressure of the atmosphere we use a BAROMETER. There are two common forms, the MERCURY BAROMETER and the ANEROID BAROMETER. Either can be made to record its own variations by the movement of a pen over a paper carried on a drum moved by clock-work. The apparatus is then called a BAROGRAPH or ANEROIDOGRAPH and the record is called a BAROGRAM.

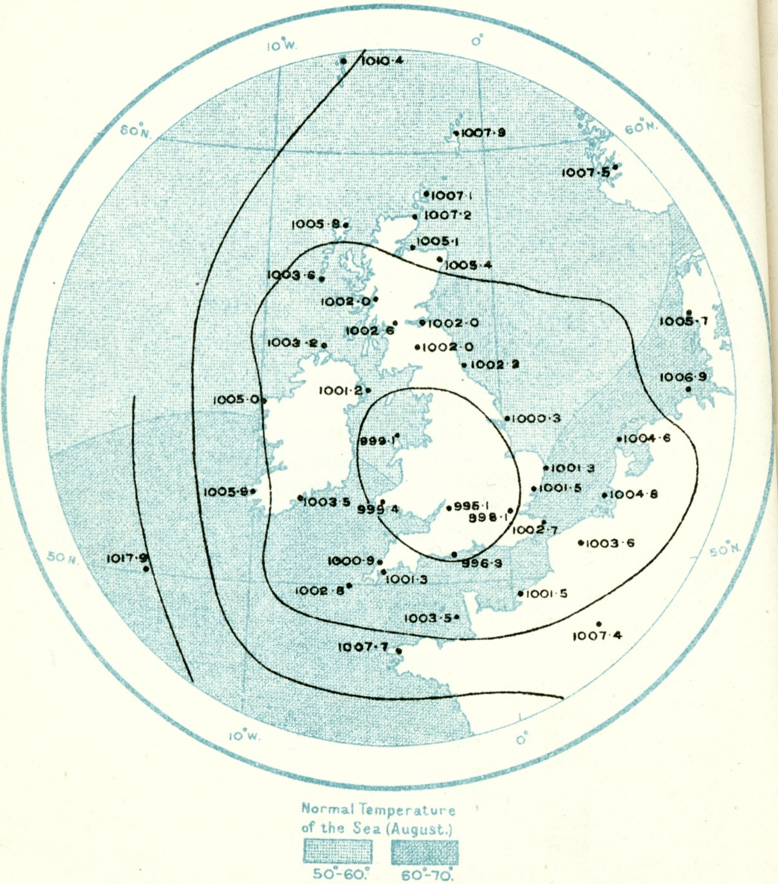
The aneroid barometer gives the best idea of what is meant by the pressure of the atmosphere, because it is the crushing, or more strictly, the compression of a box which is nearly exhausted of air and has a flexible lid, and its recovery, which move the index. In the mercury barometer it is not the pressure of the atmosphere which is measured but the length of a column of mercury which will give the same pressure as that of the atmosphere at the level where the two fluids, air and mercury, meet. Mercury is a very good fluid to use because it is so heavy. It only requires a column of mercury about 30 inches or 760 millimetres (abbreviated as 760 mm.) high, without anything on the top of it, to balance the accumulated pressure of the atmosphere in its whole range from the sea-level to a hundred miles up. Any other liquid could be used, but a water-barometer would have to be 34 feet in height, a glycerine-barometer about 27 feet in height. So in spite of the ubiquity of atmospheric pressure and the great variety of possible liquids, when it comes to measuring, only the mercury barometer and the aneroid barometer are left and there are difficulties about the use of the aneroid barometer which make it unacceptable when weather maps have to be drawn. So the mercury barometer is always used for that purpose.

It is really only small variations of atmospheric pressure that come into consideration. If we take the average pressure as a "bar" or 1000 MILLIBARS (indicated by the abbreviation mb), the whole range of variation within a year will only be between 940mb and 1060mb, except on the rarest occasions when it may include 925mb. The variation of the hundredth of an inch in the length of the mercury column or one-third of a millibar in pressure is of importance in modern weather-study, so the manufacture, graduation and reading of barometers for the purposes of a weather map are matters for

Conversion Table for Pressure.

inch	mm	mb
1	25·4	33·9
·0394	1	1·33
·0295	·75	1

DISTRIBUTION OF PRESSURE, 6 P.M. 2nd AUGUST, 1915.



The figures give the sea-level pressures in millibars.
The black lines are isobars.

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careful consideration, especially as the readings are the most important of all those which are charted. Barometer readings have to be properly examined as to temperature and INDEX ERROR, and, if necessary, CORRECTED; and they have then to be "REDUCED TO SEA-LEVEL," so that when they are plotted on the map we may recognise the variations from point to point at the same level, or along a horizontal surface. SEA-LEVEL is a conventional term to indicate the horizontal surface of the calm sea when the tide is at a particular level at Liverpool. We have already explained that if the air is at rest the pressure is the same at the same level. Now when we come to deal with large areas as with maps, we plot the readings of the barometer and find that this pressure is not the same everywhere at the same level. But when there are differences of pressure at sea-level, the air is, practically speaking, never at rest but is moving. The motion we call wind.

ISOBARS.

We can draw lines on the map which we call "ISOBARS," or lines of equal pressure which show at what points the corrected and reduced barometer readings are the same, and thus get a pictorial representation of the distribution of pressure at sea-level. These differences of pressure could not exist if the whole atmosphere were quiescent, and it is the existence of these differences which accounts, generally speaking, for the winds which we experience.

To the distribution of pressure the distribution of winds can be related and to them also, in part at least, the distribution of temperature and weather.

Plate IV represents the distribution of pressure shown by isobars and figures; when we have made a single Plate V combining all the information which has been given separately in Plates I, II, III, and IV, except temperature which the reader is requested to transfer for himself from Plate III, we have completed the weather map and the remainder of the task of modern meteorology is to understand the lessons that it teaches.

Lessons from Weather Maps.

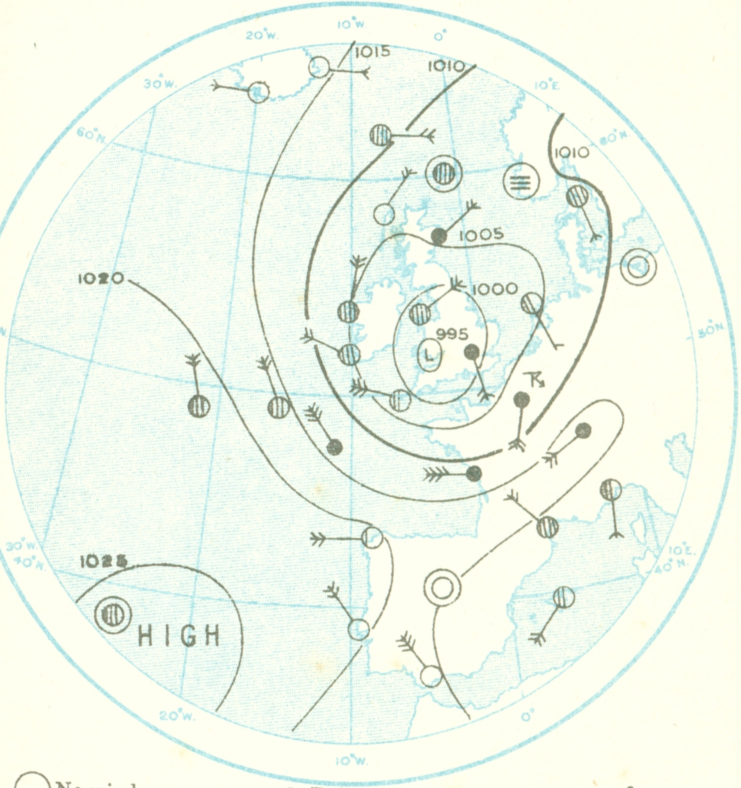
The basis of forecasting is the study of a succession of maps as will be seen later on, but let us first consider what we can learn about meteorology from the study of a single map. For this purpose some examples may be better than others, but there are some things which can be illustrated by any map.

Buys Ballot's Law.

The relation of wind to pressure, or particularly to the isobars which represent the distribution of pressure, is one of them. It will be noticed that the arrows which denote the wind, with some exceptions to which reference will be made later, take account of the run of the isobars in a peculiar manner. They mostly just fail to point along the isobars, not irregularly but with a sort of regularity. As one looks along an arrow from feathers to point it deviates from the line of the isobar in such a way that the feathers are on the side of the high pressure and the point on the side of the low; the deviation may be anything between nothing and half a right angle; in one case it is more. It is this regularity of direction, in spite of diversity in the deviation, which has attracted the attention of meteorologists and which has found expression in a law which was stated in 1857 by Professor Buys Ballot, of Utrecht, in the form that in the Northern Hemisphere **if you stand with your back to the wind, pressure is**

to face p. 26.

DISTRIBUTION OF WEATHER, WIND, AND PRESSURE, 6 P.M. 2nd AUGUST, 1915.



No wind.
Clear sky.
Half clouded.
Overcast
Rain.
One quarter clouded.
Three quarters clouded
Thunderstorm.
Mist.
Fog.

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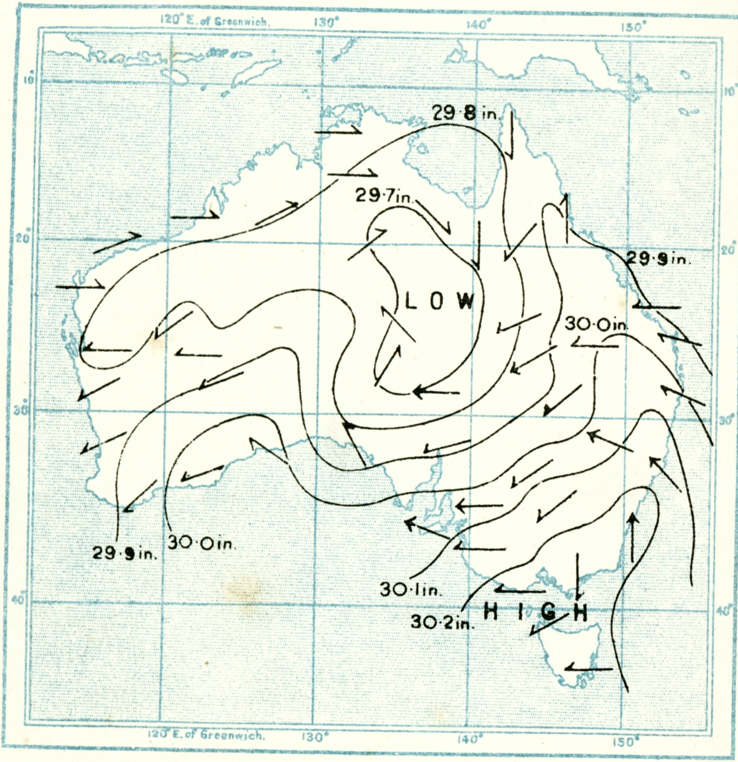
Plate VI.

to face p. 27.

CHART OF BAROMETRIC PRESSURE AND WIND, AUSTRALIA, 12th FEBRUARY, 1915.



light to moderate breeze.

fresh breeze.

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lower on your left hand than on your right. This is known as Buys Ballot's law, and is the fundamental law of modern meteorology. It is necessary to specify the Northern Hemisphere because in the Southern Hemisphere the reverse is true, standing with your back to the wind the pressure on your right hand is lower than it is on the left.

Sailors are accustomed to speak of facing the wind and in consequence, the statement of Buys Ballot's law in books on meteorology for seamen takes the form that in the Northern Hemisphere if you face the wind, pressure is lower on the right hand than on the left, and in the Southern Hemisphere if you face the wind, pressure is lower on the left hand than on the right. Plate VI is a reproduction of a map drawn by the Weather Office at Melbourne and is given here to show that with the modification mentioned, the lesson to be drawn from our maps has its counterpart in a weather-map of the Southern Hemisphere.

This remarkable change on crossing the equator naturally leads to the question of what happens in the equatorial region itself, which we may deal with at once. As a matter of fact the attention which the wind pays to the isobars is most pronounced in the polar regions, and is still quite noticeable to within 20° of the equator, but nearer the line it weakens and at the equator itself it is not operative at all. The effect diminishes as the equator is approached and is resumed in the opposite sense when a latitude of 20° on the opposite side is reached.

This gradual transition from the law of the Northern Hemisphere through the equatorial region without any law of this kind to the law of the Southern Hemisphere is not so noticeable in practice as might be expected for a special meteorological reason, arising from the series of regions of high pressure which forms a belt of permanent high pressure round each hemisphere from about 25° to 35° of latitude, and which is penetrated only by the gaps through which the trade-winds are fed. The pressure of the equatorial region itself is lower than it is in the high pressure belt, and further north or further south it falls off rapidly to certain lines of low pressure near the Arctic and Antarctic circles. Between the high pressure belts there is a large region of little or no difference of pressure and, therefore, little or no wind. So in actual experience, a traveller on his way from North to South across the line leaves the region of the Northern Hemisphere where Buys Ballot's law is effective in one way, and passes through a region of calms and variable winds, emerging again into the region of the Southern Hemisphere where Buys Ballot's law is operative in the opposite sense, without having had any opportunity of relating the wind to the pressure distribution in the intervening region.

We can look at Buys Ballot's law in a somewhat different way by considering wind as the flow of air along the surface, and we may learn from the map that air flows along the isobars round the high pressure on the right or the low pressure on the left, but with a drift across the isobars from high pressure to low pressure that gives the direction of the wind a deviation from the isobars. This way of looking at the matter is important because in recent years we have learned a good deal about the upper winds, the air currents in the free atmosphere above the surface, and one of the first conclusions from the observations of the upper air was that the flow of air was more and more strictly along the isobars in the higher levels and that the flow across the isobars is characteristic mainly of the surface winds; in other words the deviation of the wind from the isobars at the surface is perhaps attributable entirely to the indirect effect of the surface upon the flowing air.

The next important lesson to be drawn from any map refers to the strength of the wind. Hardly any map can fail to exemplify the rule that where the isobars run close together the winds are strong, and where they are wide apart the winds are weak. Any rule that could be formulated for a numerical relation between the distance apart of the isobars and the surface winds would have a good many exceptions which may be real or apparent, but, on the whole, nobody can fail to agree with the proposition that close isobars mean strong winds, and widely separated isobars light winds or calms.

An explanation of these two most important propositions, viz., Buys Ballot's law and the law of relation of wind-velocity to the distance of isobars, can be given. It connects the velocity of the wind with the distribution of pressure and the rotation of the earth, and thus accounts for the change from the Northern to the Southern Hemisphere, but the explanation obviously depends upon the theory of motion upon a rotating earth.

The calculation cannot be expected to apply fully to the surface winds because the flow of air is affected by the obstacles which it has to pass. We can attribute this interference in a general way to friction but we have no adequate numerical expression for it.

Another lesson which can be learned from a single weather map is that very little difference of pressure is accountable for a great deal of wind. If there is a fall of pressure of half an inch (16 millibars), from

London to Liverpool there is almost certainly a south-westerly gale blowing over the country between them. The smallest difference of pressure that can be recognised on a barometer is the tenth of a millibar, and to show that difference, supposing the fall all along the line from London to Liverpool to be uniform, the two barometers would have to be more than a mile apart. That means that you would have to go more than a mile to detect any difference of pressure at all at the same level, even when there is enough to cause a gale. Hence we cannot be at all sure of small local details of pressure distribution which may be operative in causing or maintaining local winds. We must not be surprised, therefore, to find that Buys Ballot's law is a somewhat general statement that may appear to lack precision and to have exceptions. It is quite possible that the exceptions would really *prove* the rule if we could map the distribution of pressure with the accuracy necessary to apply the law to the immediate locality in which we observe the wind.

Weather and Temperature.

The lessons that can be drawn from a single map about the other elements, state of the sky, weather and temperature, are mostly of a negative order.

The distribution of rain and cloud with reference to the centre of a depression on four selected occasions is shown on charts, pp. 51–54.

It will be remembered that the old barometers were engraved with certain legends against certain heights, viz.: 28·0 in. stormy, 28·5 in. much rain, 29·0 in. rain, 29·5 in. change, 30·0 in. fair, 30·5 in. set fair, 31·0 in. very dry. Consider what the result of transferring these legends to a weather map would be. Along the 28·0 isobar we should write stormy and very likely it would be true; it generally is stormy when the barometer is so low, but it can be quite stormy without the mercury falling anything like so low as that; along the 28·5 line much rain: that might or might not be true in parts; along the 29·0 line rain: that also would be true locally, but the converse proposition that it will not rain unless the barometer gets down to 29·0 in. is quite untrue. 29·5 is change, a description to which no objection need be raised; 30·0 fair: often, but not by any means always; it may rain all day with the barometer at 30·0; 30·5 set fair: it is generally fair, but there is no "set" about it; 31·0 very dry: generally true, but not necessarily 31·0 when the weather is very dry.

The worst of these legends is that though the prescribed weather does occur frequently with the barometer as described, it can and does occur with the barometer higher or lower in the scale: there is no reversibility about the propositions. If there were, how easy the study of the weather map would be. The isobars would mark out the weather, but clearly they do not. Generally speaking, weather of various kinds is to be found in different parts of the same isobar, so we cannot deal with weather on the map by assigning particular kinds of weather to particular pressures.

So, also, with temperature: to some extent it is determined by the direction of the wind, but it is modified by the action of the sea and land over which the air is passing, and the effect of the land is largely influenced by sunshine and cloud. We can only take the temperature on the map as we find it and try to connect it with the pressure and wind as modified by the sunshine.

The Sequence of Weather.

When we extend our study from separate maps to a succession of weather maps for consecutive days we obtain a further insight into the relation of weather and temperature to the distribution of pressure. This furnishes a key to the sequence of weather upon which successful forecasts can be based.

First of all it must be noted that the variety of distribution shown by the maps is endless:

"Age cannot wither her, nor custom stale Her infinite variety."

It is computed that the Daily Weather Report of the Meteorological Office for 31st December, 1916, if numbered consecutively from the beginning, should be No. 20,128. For many years maps have been prepared for three epochs for each day and are now prepared for four, so that the number of maps of the weather over the British Isles and their neighbourhood which are preserved for reference and study now exceeds 50,000. Yet the sequence, so far as we know, has never actually lost itself in repetition and we have no expectation that it ever will. We lay great stress on the behaviour of the weather being similar in its general features when similar maps recur, but none whatever upon the possibility of the recurrence of actual identity. No two maps are the same, and are not expected to be, any more than two men are the same, though many men have similar features.

The first step in the study of the sequence of weather is therefore to classify the maps; and that is done, not by dealing with the whole picture but by considering and classifying the distribution of isobars and giving names to shapes or groups which are easily recognised and which may occur in any part of the area of the map.

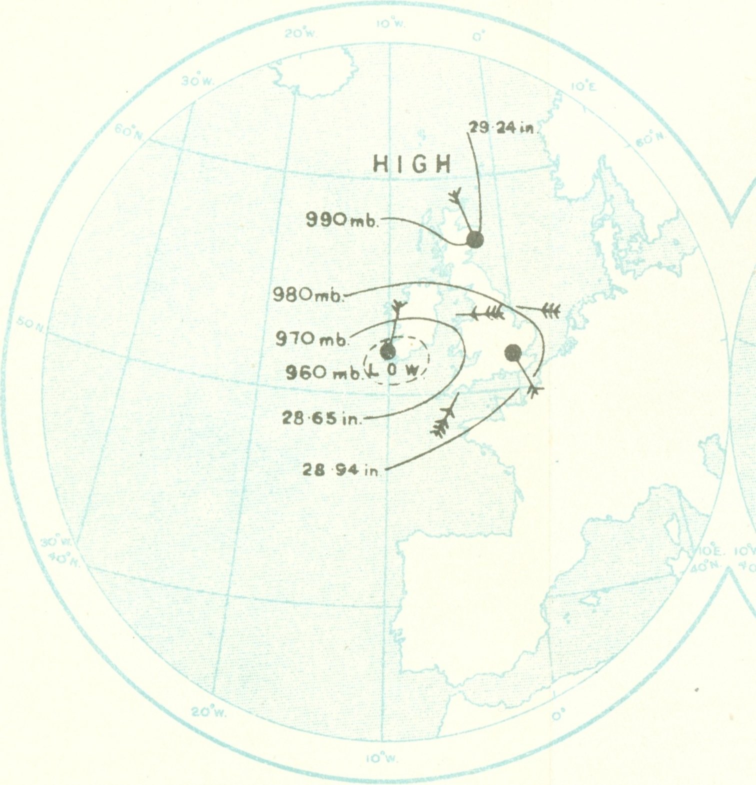
The most easily recognised group of isobars is the roughly circular group round a centre of low pressure, of which an example is shown over the British Isles in the map for 2nd August, 1915, round the centre marked L in Plate V. This is called "a cyclonic depression" or sometimes "a CYCLONE" or "a DEPRESSION" or simply "a LOW". The isobar of lowest pressure in this case is marked 995mb. and the surrounding isobars are shown as closed curves on the map until that for 1010mb., which is cut in two places by the frame of the map. It may be noticed in passing that in the end, however tortuous their paths may be, all isobars are necessarily closed curves, and it only requires a map of sufficient dimensions (with observations to fill it) in order to show the isobar as closed. No isobar can have a loose end. It is always an interesting question as to how the uncompleted isobars shown on a map are ultimately closed, and it leads to the extension of the map to cover ultimately the whole hemisphere. It is an article of faith with us that an isobar may, and often does, go round the pole, but cannot cross the line. The reason for this view is not at all recondite ; it is connected with Buys Ballot's law. The influence of one hemisphere upon the other we have not yet explored.

On the other hand, there is on the same map a region of high pressure, reaching a maximum at the Azores marked HIGH, within the isobar of 1025mb., with which, perhaps, the isobar of 1020mb. should be grouped to form an example of "an ANTICYCLONE" or "a HIGH." That particular map is sufficiently described as follows :—There is a well-marked "low" with its centre over the British Isles showing 995mb. at the mouth of the Severn, and a secondary pushing out northward along the Norwegian coast : A high of 1025mb. or more round about the Azores, with a tongue of high, 1015mb., stretching from Southern France over Eastern France between the low over Britain and a shallow low over the Mediterranean. And we can associate the weather with the distribution of pressure without much hesitation ; it is cloudy over the whole area except at the root of the projecting tongue of high, and in the North-West margin of the principal low ; there is rain along a strip across the low from South to North, forming a wide sector on the South, and a narrow strip to the North of the centre, extending as far as Aberdeen ; there are thunderstorms on the South-Eastern front.

As regards temperature the line of 60°, separating warm air from cold, runs through the centre of the low, following an irregular course from W.S.W. to E.N.E. The warm air is in the South and East, and the cold in the North and West. In the rear of the low, near the centre, the cold air has reached Scilly, with a North-Westerly wind ; and just in front of the centre the warm air has pushed northward. The line of separation between warm air and cold is roughly the line of separation between winds with a Southerly and those with a Northerly component.

This allocation of weather and temperature to certain parts of the map indicated by the distribution of pressure is quite normal, another map covered by a similar description might vary in various details, as well as in the actual figures for the temperatures, but in general outline it would fit ; but then the map for 6 p.m. of 2nd August, 1915, was carefully chosen with the object of presenting a normal, or typical, example. Other maps show various degrees of divergence from the type, or are radically different as regards the positions, areas and intensities of the "lows" and "highs," the cyclones and anti-cyclones. Every map has its own peculiarity. Every one is different in some way or other from the rest. But they nearly all have a common property which is the foundation of the modern method of forecasting

MAP 1. 11 A.M. 12th NOVEMBER, 1915.



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TRAVE

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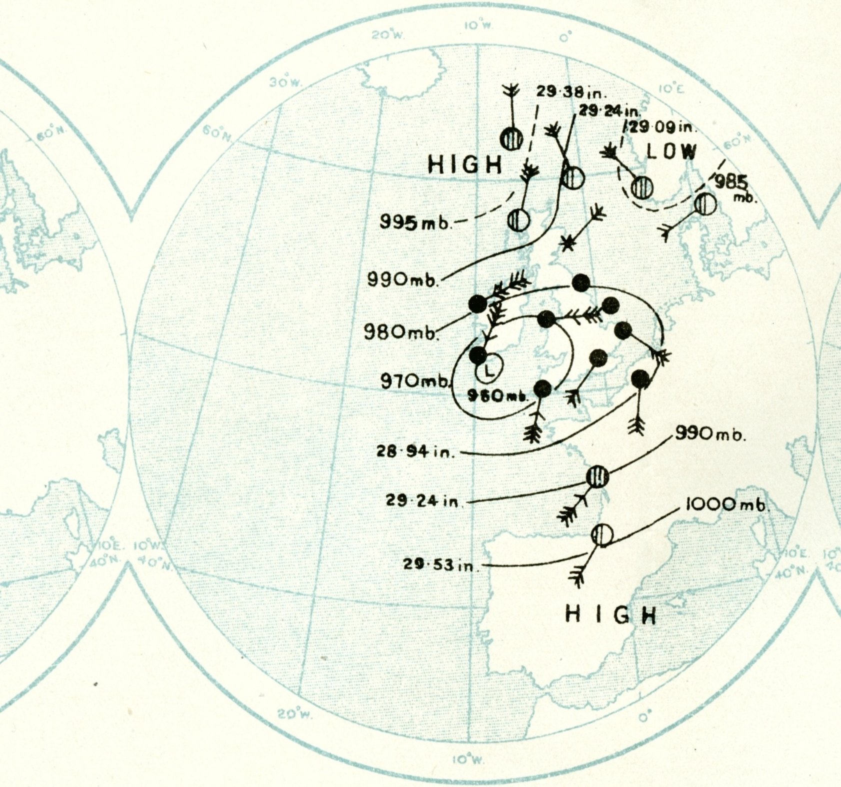
BER, 1915. MAP 2. 1 P.M. 12th NOVEMBER, 1915.



EXPLANATION :—BAROMETER.–

Force, on

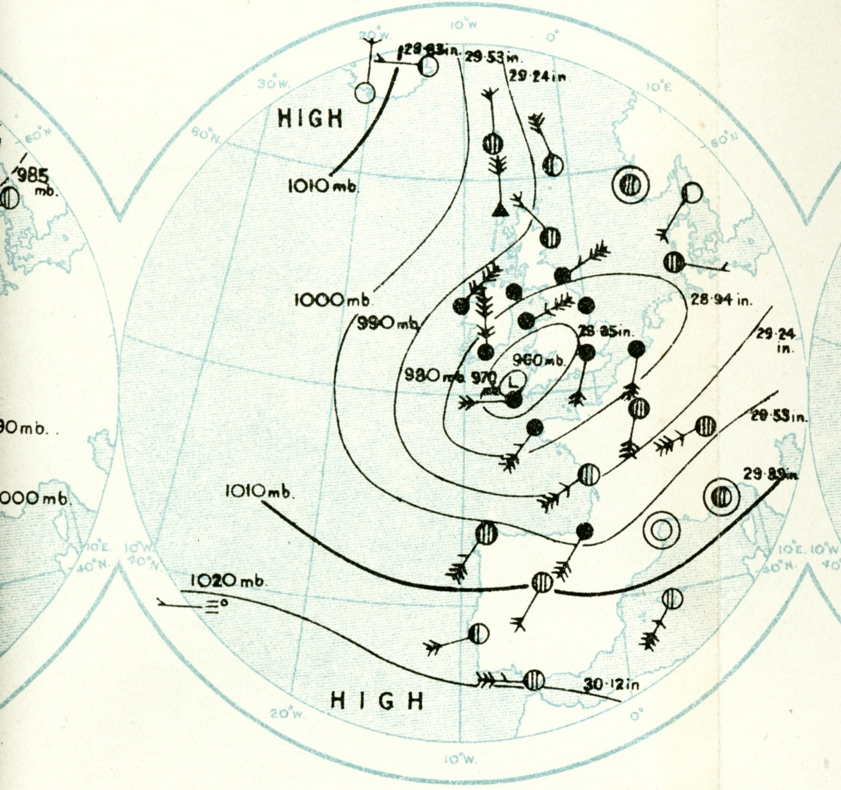
symbols :–

rain fa

TRAVELLING DEPRESSION OF NOVEMBER 12-13, 1

DISTRIBUTION OF PRESSURE, WIND, AND WEATHER.

ER, 1915. MAP 3. 6 P.M. 12th NOVEMBER, 1915.



N :—BAROMETER.—Isobars are drawn for intervals of ten millibars. WIND.—Direction is shown by

Force, on the scale 0–12, is indicated by the number of feathers. Calm ◯ WEATH

symbols :— ◯ clear sky. ◯ sky quarter clouded. ◯ sky half clouded. ◯ sky three-quarter

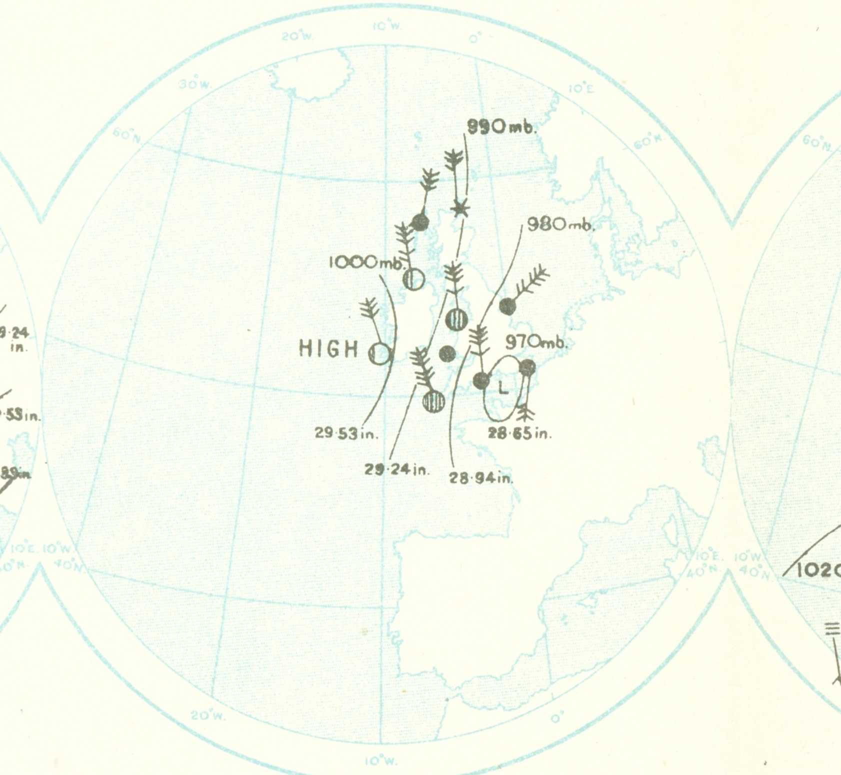
● rain falling ✳ snow. ▲ hail. ≡ fog. ≡° mist. T thunder. K thunde

-13, 1915.

HER.

15. MAP 4.

1 A.M. 13th NOVEMBER, 1915. MAP



nown by arrows flying with the wind.

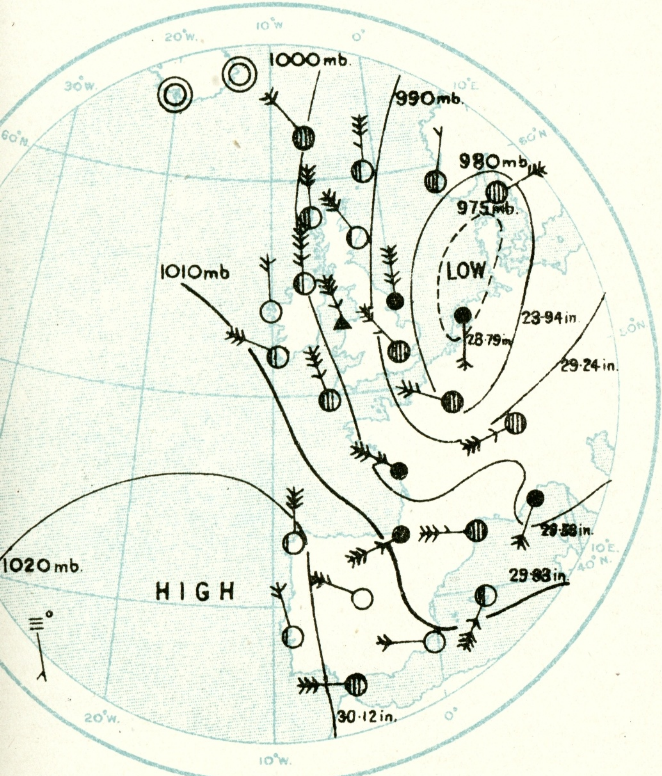
WEATHER.—Shown by the following

e-quarters clouded. ⦶ overcast sky.

thunderstorm.

Plate VII. *to face p.* 35.

P 5. 7 A.M. 13th NOVEMBER, 1915.



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weather, and that is that the main features of the distribution of pressure, the highs or lows, *travel* or perhaps *wander* across the map sometimes fast, sometimes slowly, sometimes on a straight path, sometimes on a devious one —nearly always from West to East or from South-West to North-East, or from South to North, or from North-West to South-East—rarely in the opposite directions; and yet examples do occur. We will take a normal example of the travelling of a depression, that which gave the great gales of November 12 and 13, 1915. (Plate VII.) The succession of maps for these two days which are reproduced here shows that the depression appeared first on the western margin of the map, its centre pursued a South-Easterly course until it was over Falmouth, then it made off up the Channel, crossed the land and finally disappeared across the North Sea. Another example is also given, the gale of Christmas, 1915. See Plate VIII., p. 36.

The Travel of the Centres of Cyclonic Depressions.

Cyclones and anti-cyclones are not the only forms or groups of isobars with which a meteorologist has to deal; other examples of names given to special distributions of isobars and the weather associated with them, such as straight or parallel isobars, V-shaped depression, secondary depression, sometimes called "satellite", wedge and "col" or "saddle" will be given under the heading Isobars in the Glossary. But, from the time of its identification on the first maps of isobaric lines, the association of isobars with a centre, particularly a centre of low pressure, has had an irresistible fascination for those who are interested in the study of weather. It is to the behaviour of the cyclonic depression with its associated winds and rain that they have looked for the means of formulating new laws of weather. The less obtrusive anticyclone with its generally quiet and fair, or even fine, weather has been regarded in a sort of way as a separate type of creature, resisting the approach of its mobile enemy, the cyclone, diverting him from his path while itself remaining stationary or moving only slowly and with serene dignity. So much has the cyclonic depression been regarded as the key to the secret of the weather, that, for the last forty years or more, every cyclonic depression to which a centre could be assigned on the maps of the Meteorological Office has been tracked across the map, and the path of its centre laid down and published with unfailing regularity in the Monthly Weather Report. In the earlier years we had no daily telegrams from Iceland, and we formed the idea that most of the well-behaved depressions kept to a fair track between Scotland and Iceland, where we could not map them. From the beginning of 1907 we have had the great advantage of including Iceland in our daily charts and by the end of 1916 ten years of these full charts were available for study. Mr. E. L. Hawke has recently made for me a summary of the results shown by the tracks of the depressions charted in the Monthly Weather Report for these ten years. Three conclusions drawn from this examination may be briefly mentioned here. First, 1,211 depressions have had their centres tracked in the whole period, giving, on the average, a new centre for every three days throughout the ten years. They are distributed among the calendar months as follows :—

January	91	July	88
February	94	August	89
March	133	September ...	76
April	98	October	101
May	101	November ...	103
June	102	December... ...	135

Secondly, grouping the location of the centres according to five-degree-squares of latitude and longitude, the visitations of the several squares are as set out in the following table :—

NUMBERS OF CENTRES OF DEPRESSIONS WHICH HAVE BEEN LOCATED WITHIN CERTAIN SQUARES OF FIVE DEGREES OF LATITUDE AND LONGITUDE IN THE TEN YEARS 1907 TO 1916.

LATITUDE.	LONGITUDE.				
	W. 10° to 15°.	5° to 10°.	0° to 5°.	0° to 5°.	E. 5° to 10°.
60° to 65° ...	199	244	245	221	197
55° to 60° ...	241	303	274	248	249
50° to 55° ...	288	316	292	272	203
45° to 50° ...	(105)	173	192	123	56

The geographical situation of the squares may be indicated by saying that the North-Western Square includes a corner of Iceland, the North-Eastern the extreme west of Norway, the South-Western a part of the Atlantic a long way outside the Bay of Biscay for which the number (enclosed in brackets) is probably incomplete because our supply of observations for that region is inadequate ; and the South-Eastern square includes, in its Southern part, the Swiss Alps. The middle column covers Shetland, Eastern Scotland, England and Wales, and France west of the mouth of the Seine, respectively. Looking along the rows and columns the reader will have no difficulty in discovering that Ireland is pre-eminently a locus of depressions. The square where the highest number of centres, 316, have been located is that which stretches from Scilly to Londonderry and from Valencia to St. Ann's Head; the square next in order of favour includes the North Coast of Ireland, the West Coast of Scotland and the Hebrides. The row between 50° and 55° is clearly the most frequented of all the rows until we come to the column 5° to 10° E., when the squares covering the Danish coasts come into greatest prominence. The belt from 45° to 50° has very few centres at the eastern end, but the western end gets the centres for the mouth of the English Channel and the Bay of Biscay, which are rather numerous.

Another curious point about the geographical distribution of depressions is that the centres favour different squares in different months of the year. For the ten years which have been summarised it may be noted that in January the distribution tends to uniformity. The Cattegat is the most frequented region with only 22 visitations in the ten Januarys, while England comes very near to the same number with 21. The British Isles generally get an average of 18. In February the region of the Faröe has the largest number of 30, and forms a definite centre of centres, while the average for the British squares is 21. In March the centre of centres appears in the southern part of the North Sea with the still larger number of 40, in the ten months of that name. In April the region of greatest frequency belongs to the two squares which cover Scotland, each with 25; in May the distribution is peculiar: there is a notable centre with 30 in the Irish square, but there are peculiar projections of frequency eastward to the Baltic and southward to the west of Biscay.

The month of June brings us back again to Eastern Scotland with a well-defined concentration of 32 centres. In the next month, July, the same square is again pro-minent associated with its western neighbour as it was in April, but credited this time with 29 each, and in August the same figure is set against the same two squares, and against the adjoining Irish square as well, while the English square comes pretty near with 27. September is the month when depressions are fewest; in the ten years most centres have been located in the South Norway–Denmark square, but the number only reaches 20. In October there is a recrudescence of activity in which Ireland with St. George's Channel becomes the most frequented district with 36 depressions in the ten years. The same locality is relatively even more locally pro minent in November, although the number of centres which crossed the square is only 32. There is a secondary centre of frequency with 27 in the Shetland region. Still more marked again is the predominance of the same region (Ireland with St. George's Channel) in December, for in the months of that name in the ten years, that region has been credited with no fewer than 43 centres.

The third conclusion which has been drawn is that in their tracks across the region under consideration the centres of depressions seem to choose either the waterways of the English Channel, the North Channel or St. George's Channel into the Irish Sea or pass beyond the northern coasts. When they cross the land they choose the flat parts of it. They cross Ireland, for example, by the level middle, and thence go by mid-Wales or the Solway Firth over England; or they come from the North-West to the Irish Sea. Another route is from the Bristol Channel to the mouth of the Thames, another from Cardigan Bay to the Wash or to the mouth of the Thames, another from the Mersey to the mouth of the Thames, in continuation of the route from North-west by the North Channel. There are also favourite crossings from sea to sea by the Solway Firth, as already mentioned, for depressions which have reached the Irish Sea and by the Clyde and Firth of Forth, or by the short cut from the Minch to the Moray Firth for centres which approach the Scottish coasts from the westward. The selection of these routes is not a matter of law, but rather of facility. Exceptions could probably be found to all of them.

A peculiarity of the routes is that they seem to be available either way. A depression may pass from the Bay of Biscay northward over the Irish Sea and so on to the North-West, or it may travel in the reverse direction, and may even retrace its own path. It may travel from the Hebrides to London via Liverpool, or from London to the Hebrides by the same route.

Not too much stress must be laid upon the precise lines representing the tracks, as the centre of a depression is an elusive point, but all the accumulated evidence goes to show that the travel of a cyclonic depression is not a very simple matter. It used to be thought that a cyclonic depression was a great whirling mass of air that passed over the country with other smaller whirls appearing as secondaries. The use of the word "satellite", which was at one time quite popular, was intended, somewhat unfortunately, to give the idea of a revolving moon travelling in the train of a larger revolving earth. We are now able to say quite definitely that the general motion of air in a cyclone outside the tropics is different from that of a whirlwind: the ascertained motion of the centre on a map is the direct consequence of the motion of the air in the cyclone itself and part of it; it is not the general motion of the current in which the whirl is contained. A whirling mass of fluid carried along by the general current does sometimes appear on the map, but not at the central area of one of our travelling depressions, where there is cyclonic motion which we do not yet fully understand. We may find a whirling mass where American meteorologists find their tornados: "as the attendants of the parent cyclones of which they are the offspring. They are born in the great majority of cases in the area of warm, damp southerly winds . . . . in front of a general cyclonic storm."*

The motion of a cyclonic depression is not a dervish whirl; it is a peculiar kind of dance which it would be quite worth while for children to try to perform, in which the dancers or the samples of air are always changing their partners: the ring which appears on the map is always being freshly formed of new elements from neighbouring rings. Only the sample which travels with the speed and direction of the centre keeps its place and that not by moving in a circle but by going *straight on;* all the rest march round the centre and away again, never get in each other's way and always fill the stage. Each one takes a step in a circle and the next step in another circle, and a third in a third circle. Every step is in a circle, but no two consecutive steps are in the same circle. The dance is much too regular to be at the mercy of such accidents as warm air and cold air. It takes those in as incidental circumstances without much inconvenience, as the study of the maps of depressions will show.

Barometric Tendency.

It is the business of the forecaster to find out, if he can, in what direction the cyclonic depressions or anticyclones within his region are going to move, and to issue notices of the changes of wind and weather that are incidental to

* Robert de C. Ward, Q.J.R. Met. Soc.

the motion. For that purpose he relies mainly on what is called the BAROMETRIC TENDENCY, and the recent changes in the direction and force of the wind at all the reporting stations, which are denoted by the terms BACKING and VEERING.

The barometric tendency at any station is the change in the pressure at the station within the three hours immediately preceding the fixed hour of observation. It is taken from the record of a barograph and, by an international agreement of 1913, it is included in the regular reports from all stations that are provided with barographs. For our own stations the change of pressure indicating the tendency is given in half-millibars, because that represents the highest degree of accuracy with which the change can be read from the trace of the pen of an ordinary barograph.

When the barometric tendencies are entered on the map it is easy to identify the regions where the barometer is in process of falling, and those where it is in process of rising; and this information gives a general idea of the changes of pressure that are in progress on the map. The barometric tendency is the more useful because a cyclone or anticyclone seldom travels unchanged in shape and intensity. The travel of *pressure-changes* is apparently more regular than the travel of *pressure-values*.

Some addition is made to the definiteness of the indications by transmitting also what is called the *characteristic of the tendency* according to an agreed code which tells whether the rise or fall is increasing or slackening, or is in process of reversal, and so on.

VEERING AND BACKING OF WIND.

The other chief indication of impending changes in the map is the change in the wind at the several stations.

We know from Buys Ballot's law that the direction of the wind tells us in what direction to look for higher pressure and for lower pressure; and, when the wind changes, we must recognise that the distribution of pressure is changing also. If the *force* of the wind alone changes while its direction holds, we know that closer or more widely spread isobars are passing over us; when the *direction* of the wind is changing the highs and lows must be changing their ORIENTATION.

The best examples of the usefulness of this indication are afforded when cyclonic depressions follow one another in succession, at intervals of two days or thereabouts, along their favourite track from W.S.W. to E.N.E., with the centre somewhere northward of Britain. When the centre has passed, the wind is North-Westerly; the low is to the left of the wind to the North-East—gone by—higher pressure is to the right, South-west—to come. If the wind presently BACKS, as it is called, from North-West (against clock-hands) through West to South-West again, the higher pressure has gone by, and another low is approaching. As the low passes, the wind VEERS (with clock-hands) through West to North-West.

The amount of veering or backing is usually settled by the forecaster for himself by a comparison of the record on the map with that on the preceding map. In the absence of wireless reports the backing of the wind at Valencia or Blacksod Point on the West coast of Ireland is the first indication on the map of the approach of a new depression from the Atlantic.

Types of Pressure Distribution.

The process of classification which has been described in the preceding paragraphs is limited to the consideration of the shapes and groups of isobars; the positions of the characteristic groups have to be specified in order to define the meteorological conditions. A good deal of labour has been devoted to the method of classification by reference to the whole picture disclosed by the map. With patience and perseverance typical maps may be selected, and other maps classified according to the selected types. Rules have even been formulated about the duration of particular types and the sequence of types—but they are not very satisfying.

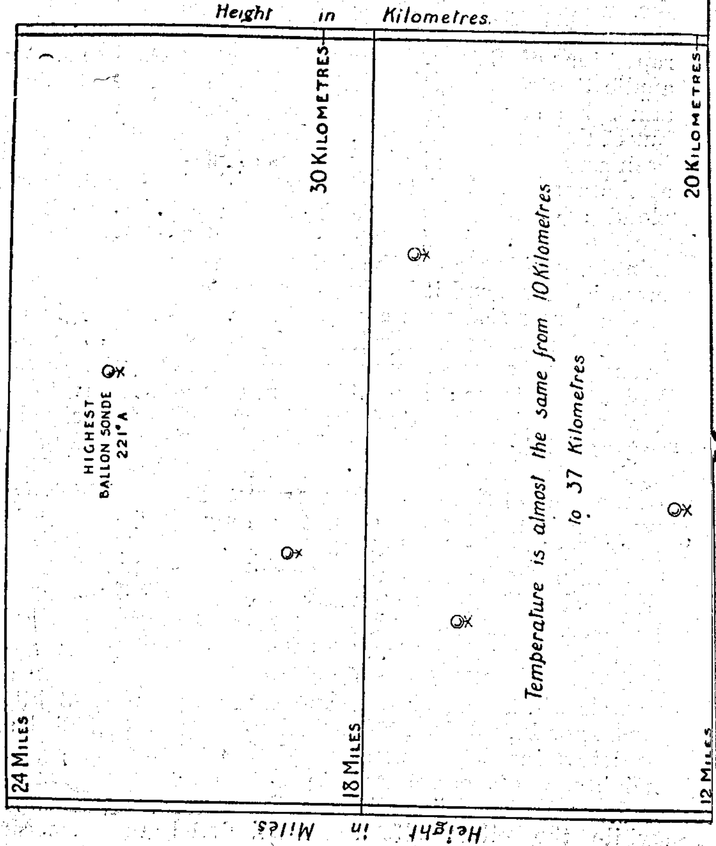
THE UPPER AIR.

THE DYNAMICS AND PHYSICS OF THE ATMOSPHERE.

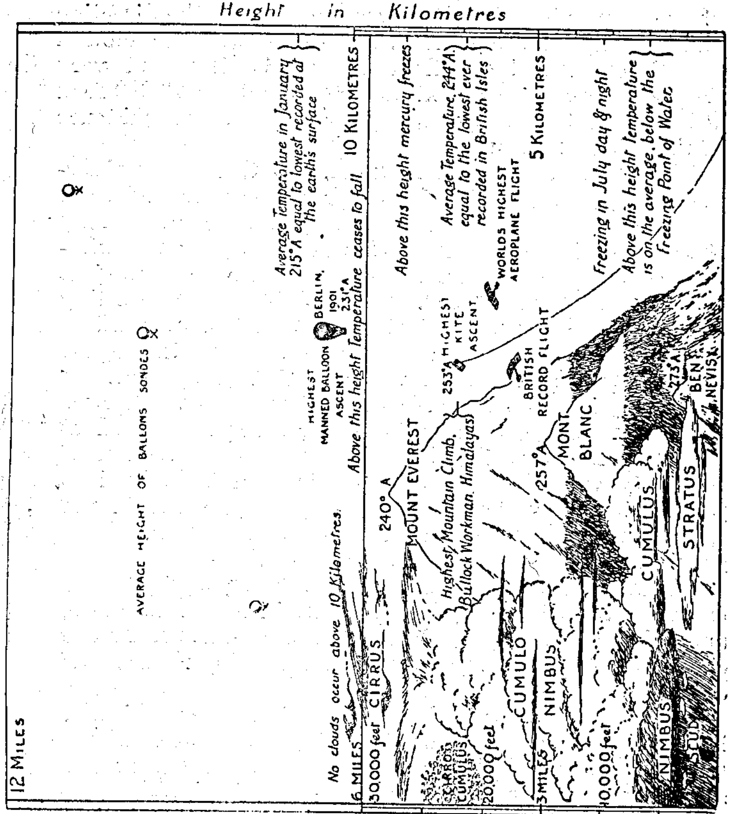
The study of the details of pressure-distribution and its changes which enable the forecaster to give precision to his forecasts is a matter of prolonged experience with weather maps, the results of which have never been formulated and cannot be set out fully without the maps themselves. It is not dependent upon any elaborate training in mathematics or physics. Anyone with an ordinary school-education can acquire the necessary experience. But when experience has done its best the most accomplished forecaster from weather maps finds himself confronted again with the fact that he cannot hope to come upon a complete and perfect repetition of a sequence which has occurred before. There is always the margin of the unexpected.

We do not, on that account, consider that the comprehension of the events which the observer records will be for ever beyond our reach; we are only stimulated to ascertain the physical causes of the variations which are shown upon the map, so that we may deal with them as events following causes, instead of regarding them as the repetitions of history. That is the general problem of the application of the sciences of dynamics and physics to the atmosphere, and it is a problem of the highest interest, but of the utmost difficulty. For two generations it has been assiduously studied by means of observations taken at the surface, aided to some extent by observations of clouds; but the progress has been disappointing, perhaps for the reason that it has been confined chiefly to the minute specification of the details of the average cyclone or anticyclone, and it has been hampered by the fact that we have no satisfactory account to give of the origin of the cyclones and anticyclones themselves. We are not even sure that the average cyclone or anticyclone ever had an existence; a combination of means may be a creature of the computer's machinery and never occur in nature at all; nor are we really in a position to say that cyclones and anticyclones are the fundamental expression of the general circulation of the atmosphere, of which our weather is the local expression; they may be merely incidents in that circulation.

Within the last twenty years the available facts of meteorology have been greatly increased by using kites, balloons, BALLONS-SONDES and PILOT-BALLOONS for the study of the upper air. The first two have given us a wealth of detail of the structure of the atmosphere as regards wind, temperature and humidity up to 3 kilometres or 10,000 feet. The ballon-sonde has enabled us to determine the temperature of the air up to very great heights, on one occasion up to 36 kilometres or 22 miles, and on many occasions up to 20 kilometres (see Glossary); while the pilot-balloon has disclosed the structure



The Stratosphere from 12 to 24 miles.



The Troposphere and lower region of the Stratosphere.

of the atmosphere in clear weather, that is the direction and velocity of the wind when there were no clouds, sometimes beyond 10 kilometres, or 6 miles, and very frequently up to 3 or 4 kilometres, 10,000 or 13,000 feet. It is now in daily use at many stations for the guidance of the pilots of aircraft.

We have learned from the results of these new observations that the distribution of pressure at the surface in our region is most probably governed or controlled by the distribution of pressure at a height of about 9 kilometres, the layer at the top of the TROPOSPHERE, just below the STRATOSPHERE. The air below that controlling level, although it comprises two thirds of the whole atmosphere, has comparatively little to say with regard to the general outlines of the distribution of pressure.

We may infer that our local experiences of weather are the results of the distribution of pressure prescribed at that very high level, and affected by the convection of relatively warm and cold air which are brought into juxtaposition by the operation of pressure within the region intervening between the governing layer and the ground.

It remains for us to find out, if we can, what are the causes of the distribution of pressure in the stratosphere, and what are the conditions for the occurrence of the convection that expresses itself in clouds, rain, snow or hail.

To do this requires the co-operation of the highest ingenuity in devising and carrying out observations, with the most ample intellectual equipment that the sciences of mathematics and physics can supply.

No student of weather-maps based upon meteorological observations can afford to be shy of decimals, MEANS

AVERAGES and NORMALS; and he must know something about astronomy and physical geography; if he wishes to pursue the daily investigation of the structure of the atmosphere with pilot-balloons he must face the terrors of the elementary trigonometry required for the solution of triangles. In thinking about the facts as to winds disclosed by pilot-balloons in relation to pressure he will find himself involved in DYNAMICS of a peculiarly difficult type. If he wishes to find out the height of a balloon from the record of its pressure and temperature he will require a working knowledge of practical physics, with a little mathematics added, that will inevitably land him in an exponential territory, the region of logarithms.

It is not given to everyone to acquire the equipment which these difficult sciences provide—not that they are too difficult, for difficulty in these matters is only a want of familiarity—but familiarity requires a long time, and time is notoriously short. It is therefore not possible to complete this introduction to modern meteorology by preliminary dissertations on the mathematics, dynamics, astronomy and physics which the modern meteorologist uses. Nor is it necessary, because this is a matter of co-operation; observation is as indispensable for the result as calculation, and, if there is a reasonable and candid exchange of experiences, the division of labour is the best arrangement.

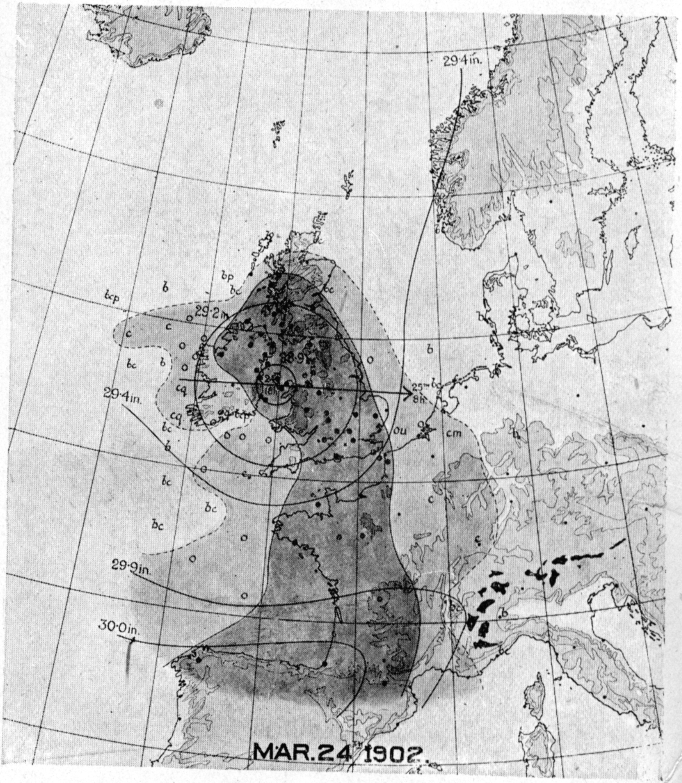
But, at the same time, everybody is interested in the weather, and most men have at some time or other acquired a store of knowledge which will enable them to make intelligent use of the information which modern meteorology provides. Much of it is concerned with unfamiliar words, some of it with unfamiliar ideas. It seems therefore desirable to follow the plan of the dictionary or the encyclopædia, and put together such information as may be of interest to the practical students of weather in the form of separate short articles, in alphabetical order of subject, forming the Meteorological Glossary (M.O. 225 ii).

To this Glossary have been assigned such meteorological details as the different forms and groups of isobars, the classification of clouds, the frequency of gales and fogs, and articles on other topics of interest concerning weather and climate. There will appear also brief explanations of many technical meteorological terms, and short articles on the dynamical, astronomical, or physical subjects that are indispensable for those who desire to follow in greater detail the recent progress of the study of weather.

Charts of the Distribution of Rain and Cloud in Cyclonic Depressions.

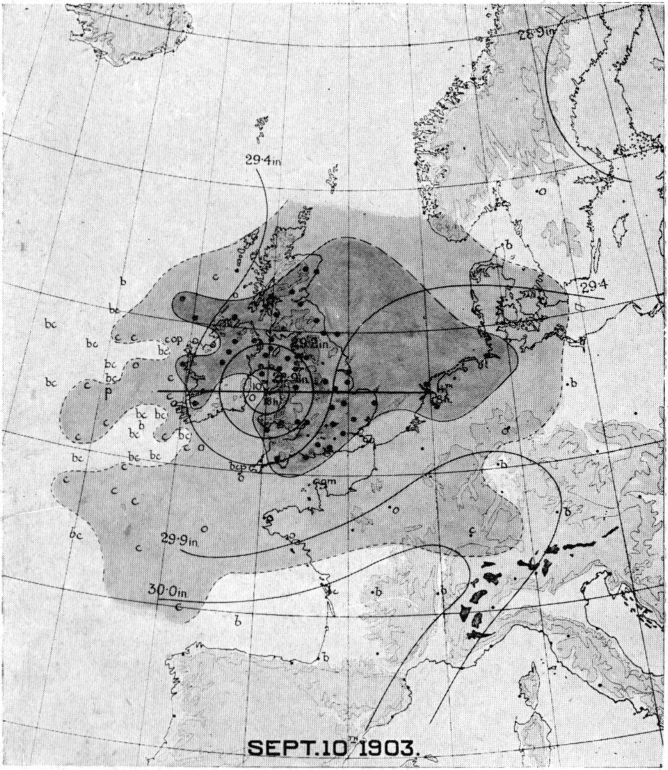
In amplification of the note on p. 30 the reader's attention is invited to the results of some attempts to combine the information about weather from successive maps in order to obtain a correct view of what, on the whole, a cyclonic depression really means for the regions over which it passes. For this purpose maps have been constructed representing notable depressions in successive stages at intervals of one hour or two hours during their travel over our islands, and out of the whole set of maps for each depression a composite chart has been made by placing on one of the maps the proper symbols for all the observations of blue sky, cloud or rain at the proper position *with regard to the centre of the depression* at the times of the observation. The results are given in the four diagrams which follow. The irregularity of the shape of the rain-area is very noteworthy, particularly in the case of November 1915.

DISTRIBUTION OF RAIN AND CLOUD WITH REFERENCE TO THE CENTRE OF A QUICK-TRAVELLING DEPRESSION ON MARCH 24–25, 1902. (FROM THE LIFE-HISTORY OF SURFACE AIR-CURRENTS.)



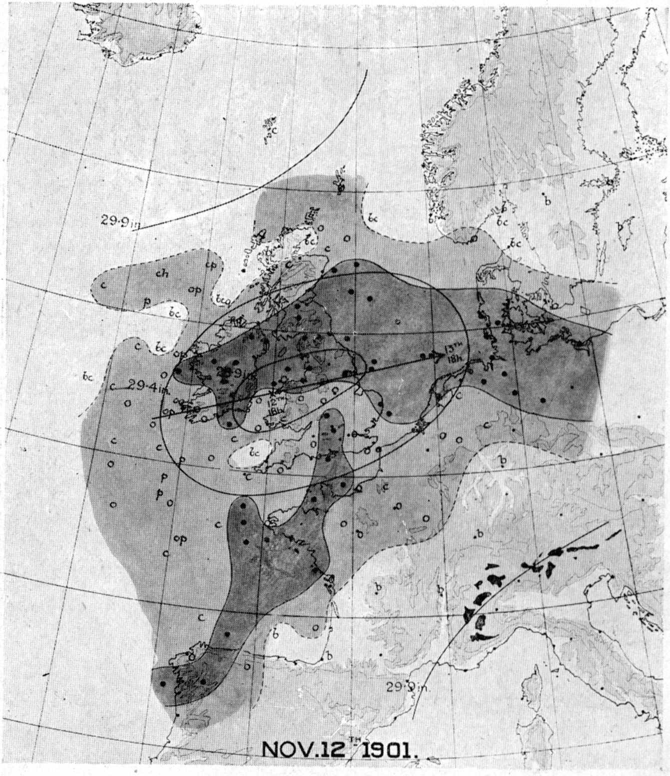
The dark shading shows the "rain-area," the lighter shading surrounding it the "cloud-area." The weather-shading must be distinguished from the contour-shading which is shown over the land.

DISTRIBUTION OF RAIN AND CLOUD WITH REFERENCE TO THE CENTRE OF A QUICK-TRAVELLING DEPRESSION ON SEPTEMBER 9–10, 1903. (FROM THE LIFE-HISTORY OF SURFACE AIR-CURRENTS.)



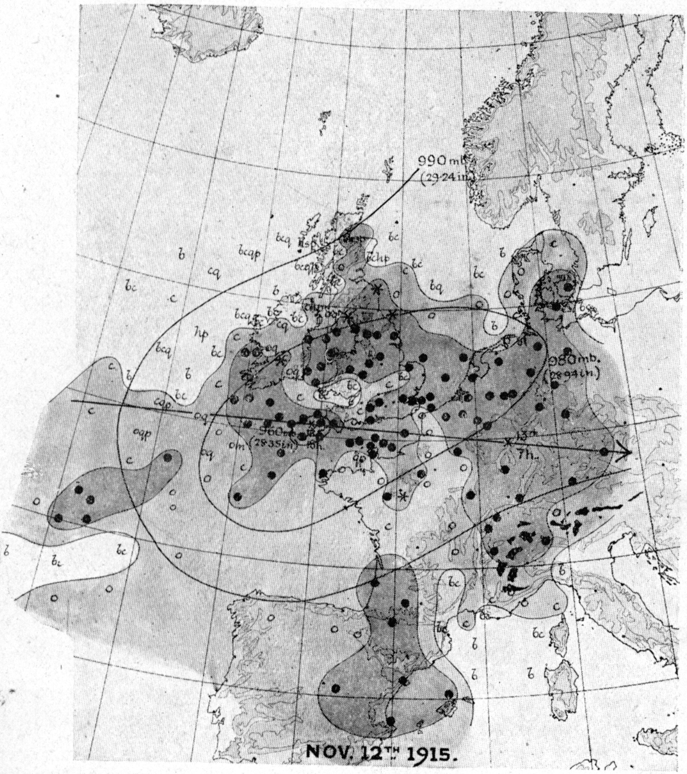
The dark shading shows the "rain-area," the lighter shading surrounding it the "cloud-area." The weather-shading must be distinguished from the contour-shading which is shown over the land.

DISTRIBUTION OF RAIN AND CLOUD WITH REFERENCE TO THE CENTRE OF A TRAVELLING DEPRESSION, NOVEMBER 12–13, 1901. (FROM THE LIFE-HISTORY OF SURFACE AIR-CURRENTS.)



The dark shading shows the "rain-areas," the lighter shading surrounding them the "cloud-area." The weather-shading must be distinguished from the contour-shading which is shown over the land.

Distribution of rain and cloud with reference to the centre of the depression of November 12–13, 1915. (See Plate VII.)



The dark shading shows the "rain-areas," the lighter shading surrounding the " the "cloud-area." The weather-shading must be distinguished from the contour-shading which is shown over the land.

CLIMATOLOGICAL SUPPLEMENT

COMPRISING

CLIMATIC SUMMARIES

FOR

LONDON (KEW OBSERVATORY);

PARIS (PARC ST. MAUR);

BALKAN PENINSULA (PHILIPPOPOLI);

MESOPOTAMIA (BABYLON);

EGYPT (HELWAN OBSERVATORY);

EAST AFRICA (DAR ES SALAM);

CHARTS OF NORMALS OF TEMPERATURE, SUNSHINE AND RAINFALL FOR THE BRITISH ISLES, AND CLIMATIC DIAGRAMS REPRESENTING NORMAL HOURLY VALUES OF TEMPERATURE, PRESSURE, WIND-VELOCITY, RAINFALL AND HUMIDITY IN THE SEVERAL MONTHS OF THE YEAR AT FOUR OBSERVATORIES OF THE METEOROLOGICAL OFFICE.

CLIMATOLOGICAL SUPPLEMENT.

Climatic Summaries.

Climatology is the professional expression of the meteorologist's memory. The facts to be represented are all the incidents noted by the observers at the time. A full climatological return for a station observing three times a day runs to 57 entries per day, roughly 20,000 a year, a "lakh" in 5 years. It is the business of a climatological summary to take account of every one of those items, and precisely to the extent which it deserves. If a particular item is a salient fact that might have a definite bearing on human life and health, it ought to make itself felt in the summary and not to be obliterated by multitudes of others that are only of ordinary importance. So the problem of co-ordinating the "lakh" of facts for a 5-years' table and selecting those which are to be pushed into the numerical foreground is by no means an easy one.

Means and Extremes: Normals.

The most usual method of procedure is to prepare a series of monthly means, or totals, and extremes, for all those elements which are represented by numerical or instrumental readings, such as pressure, maximum and minimum temperature, absolute and relative humidity, rainfall and sunshine. The means are obtained by taking the set of readings for the month, adding them together and dividing by the number in the set. In the case of pressure, temperature and humidity, for which the monthly total suggests nothing to the reader, it is usual to take the mean value of the set of observations in each month, and the result may be called the daily mean value, but with rainfall as measured in millimetres or inches, and sunshine as measured by its duration in hours, it is usual to give the mean monthly totals—a bad meteorological habit really, because though there are twelve months to the year, a calendar month is not the twelfth part of a year, and the resultant figures for the months are not properly comparable. There is, for example, among our publications a set of diagrams of the rainfall of London in the hundred years 1813–1912; the final diagram shows the mean monthly rainfall for the whole period and in it February stands out, or more strictly speaking, recedes as the least rainy month of the whole year. So it is, because there are only 28 days in February with an occasional 29, as against 31 for January and March on either side of it. It is not the least rainy period of the year, and when allowance is made for the number of days of the month we arrive at the interesting truth that a February day is intermediate in its allowance of rainfall between a January day which has more and a March day which has less.

Hence, though the months are convenient labels for different parts of the year it is a mistake—albeit an almost universal one—to use them for monthly totals for rainfall and sunshine. At the Meteorological Office we have had the courage to break away from the habit in the case of sunshine, fortified by the consideration that so many "hours a day" of sunshine is a more suggestive figure than so many hours a month, but we have not yet had the courage, as we ought to have, to deal in the same way with rainfall.

Averages and Normals.

The word "average" borrowed from ancient shipping law, is used to denote mean values for a sufficient number of years to be reasonably inclusive of the vicissitudes to be expected, and when the number of years over which the observations extend is such that the process of totalling and meaning has reached the limit of its potency and its further extension will make no practical addition to its value, we use the word "normal" to describe the series of values obtained as the final result. Thirty-five years are the period which we like for normals. Perhaps later on we may run to 50 years or even 100 years, because when we have got our normals we always want to know how the values of the current year differ therefrom. But for newly-settled countries we are apt to signify our pleasure at obtaining a homogeneous series of observations for so long a period as ten years by dignifying the mean values with the title of 10-year normals.

Means are always useful but sometimes dull and uninforming. Extremes are interesting and useful too as setting the limits of what humanity must be prepared to put up with if it wishes to carry on operations in the locality represented by the figures. The recitation even of these simple forms of climatic information is not without certain risks of being misunderstood because everybody knows but does not always remember that places close together may certainly have different extremes and, to some extent, different means if they have different height or aspect; if, for example, they are on opposite sides of a river-valley or a mountain-ridge on the coast; or on the coast-range. The climate of the Balkans, for example, requires not simply a table but a book.

Frequencies.

Means are not of much practical value if they obliterate a regular variation between day and night; I have endeavoured to avoid this disadvantage by giving the normal values of means or frequency of occurrence at fixed hours, 7 h., 13 h. and 18 h. of local mean time.

When we pass beyond means and extremes, the normal monthly frequency of occurrence of occasions of definite importance as regards the various elements of weather seems to be the best guide to the climate of a region for anyone who is responsible for the welfare of people who have to live there; and consequently the frequencies of rainfall in various forms, of temperature within certain limits, of wind-forces or barometric gradients, if possible, and if not, of wind-directions; and of days with fogs.

It may shock some readers to find that in these tables the values of the meteorological elements are arranged according to metric units and that temperatures are quoted to the so-called absolute scale of centigrade degrees, so that the freezing-point figures as 273a. This goes a little beyond the province of the meteorologist's professional memory, but memory is most useful if it can be arranged to make its application most effective. If it is a mere question of memory, for example, whether it is now colder or hotter than it was years ago, any scale will serve, but to bring the facts into relation with the physical conditions and their changes, a suitable scale is of some importance.

To obviate any difficulty, we give here a table of the equivalents of millibars and inches, degrees absolute, centigrade and Fahrenheit, millimetres and inches, metres per second and miles per hour.

TABLE I.—CONVERSION OF BAROMETRIC HEIGHT IN INCHES OF MERCURY AT 32°F., LATITUDE 45°, TO ATMOSPHERIC PRESSURE IN MILLIBARS.

Ins.	Milli-bars.	Ins.	Milli-bars.	Ins.	Milli-bars.	Ins.	Milli-bars.	Ins.	Milli-bars.	Ins.	Milli-bars.
28·00	948·2	28·50	965·1	29·00	982·0	29·50	999·0	30·00	1015·9	30·50	1032·8
2	48·8	2	65·8	2	82·7	2	99·6	2	16·6	2	33·5
4	49·5	4	66·5	4	83·4	4	1000·3	4	17·3	4	34·2
6	50·2	6	67·1	6	84·1	6	01·0	6	17·9	6	34·9
8	50·9	8	67·8	8	84·7	8	01·7	8	18·6	8	35·5
28·10	51·6	28·60	68·5	29·10	85·4	29·60	02·4	30·10	19·3	30·60	36·2
2	52·2	2	69·2	2	86·1	2	03·0	2	20·0	2	36·9
4	52·9	4	69·8	4	86·8	4	03·7	4	20·6	4	37·6
6	53·6	6	70·5	6	87·5	6	04·4	6	21·3	6	38·2
8	54·3	8	71·2	8	88·1	8	05·1	8	22·0	8	38·9
28·20	54·9	28·70	71·9	29·20	88·8	29·70	05·7	30·20	22·7	30·70	39·6
2	55·6	2	72·6	2	89·5	2	06·4	2	23·3	2	40·3
4	56·3	4	73·2	4	90·2	4	07·1	4	24·0	4	41·0
6	57·0	6	73·9	6	90·8	6	07·8	6	24·7	6	41·6
8	57·7	8	74·6	8	91·5	8	08·4	8	25·4	8	42·3
28·30	58·3	28·80	75·3	29·30	92·2	29·80	09·1	30·30	26·1	30·80	43·0
2	59·0	2	75·9	2	92·9	2	09·8	2	26·7	2	43·7
4	59·7	4	76·6	4	93·5	4	10·5	4	27·4	4	44·3
6	60·3	6	77·3	6	94·2	6	11·2	6	28·1	6	45·0
8	61·0	8	78·0	8	94·9	8	11·8	8	28·8	8	45·7
28·40	61·7	28·90	78·6	29·40	95·6	29·90	12·5	30·40	29·4	30·90	46·4
2	62·4	2	79·3	2	96·3	2	13·2	2	30·1	2	47·1
4	63·1	4	80·0	4	96·9	4	13·9	4	30·8	4	47·7
6	63·7	6	80·7	6	97·6	6	14·5	6	31·5	6	48·4
8	64·4	8	81·4	8	98·3	8	15·2	8	32·2	8	49·1

DEGREES FAHRENHEIT INTO DEGREES

TABLE II.—CONVERSION OF DEGREES FAHRENHEIT INTO DEGREES CENTIGRADE AND DEGREES ABSOLUTE.

F.	°C.	a.	°F.	°C.	a.	°F.	°C.	a.	°F.	°C.	a.
20	−6·7	266·3	45	7·2	280·2	70	21·1	294·1	95	35·0	308·0
21	−6·1	266·9	46	7·8	280·8	71	21·7	294·7	96	35·6	308·6
22	−5·6	267·4	47	8·3	281·3	72	22·2	295·2	97	36·1	309·1
23	−5·0	268·0	48	8·9	281·9	73	22·8	295·8	98	36·7	309·7
24	−4·4	268·6	49	9·4	282·4	74	23·3	296·3	99	37·2	310·2
25	−3·9	269·1	50	10·0	283·0	75	23·9	296·9	100	37·8	310·8
26	−3·3	269·7	51	10·6	283·6	76	24·4	297·4	101	38·3	311·3
27	−2·8	270·2	52	11·1	284·1	77	25·0	298·0	102	38·9	311·9
28	−2·2	270·8	53	11·7	284·7	78	25·6	298·6	103	39·4	312·4
29	−1·7	271·3	54	12·2	285·2	79	26·1	299·1	104	40·0	313·0
30	−1·1	271·9	55	12·8	285·8	80	26·7	299·7	105	40·6	313·6
31	−0·6	272·4	56	13·3	286·3	81	27·2	300·2	106	41·1	314·1
32	0·0	273·0	57	13·9	286·9	82	27·8	300·8	107	41·7	314·7
33	+0·6	273·6	58	14·4	287·4	83	28·3	301·3	108	42·2	315·2
34	1·1	274·1	59	15·0	288·0	84	28·9	301·9	109	42·8	315·8
35	1·7	274·7	60	15·6	288·6	85	29·4	302·4	110	43·3	316·3
36	2·2	275·2	61	16·1	289·1	86	30·0	303·0	111	43·9	316·9
37	2·8	275·8	62	16·7	289·7	87	30·6	303·6	112	44·4	317·4
38	3·3	276·3	63	17·2	290·2	88	31·1	304·1	113	45·0	318·0
39	3·9	276·9	64	17·8	290·8	89	31·7	304·7	114	45·6	318·6
40	4·4	277·4	65	18·3	291·3	90	32·2	305·2	115	46·1	319·1
41	5·0	278·0	66	18·9	291·9	91	32·8	305·8	116	46·7	319·7
42	5·6	278·6	67	19·4	292·4	92	33·3	306·3	117	47·2	320·2
43	6·1	279·1	68	20·0	293·0	93	33·9	306·9	118	47·8	320·8
44	6·7	279·7	69	20·6	293·6	94	34·4	307·4	119	48·3	321·3

Table III.—Rainfall. *Inches to Millimetres.*

Inches.	0	1	2	3	4	5	6	7	8	9
	Millimetres.									
0·0	0·00	0·25	0·51	0·76	1·02	1·27	1·52	1·78	2·03	2·29
0·1	2·54	2·79	3·05	3·30	3·56	3·81	4·06	4·32	4·57	4·83
0·2	5·08	5·33	5·59	5·84	6·10	6·35	6·60	6·86	7·11	7·37
0·3	7·62	7·87	8·13	8·38	8·64	8·89	9·14	9·40	9·65	9·91
0·4	10·16	10·41	10·67	10·92	11·18	11·43	11·68	11·94	12·19	12·45
0·5	12·70	12·95	13·21	13·46	13·72	13·97	14·22	14·48	14·73	14·99
0·6	15·24	15·49	15·75	16·00	16·26	16·51	16·76	17·02	17·27	17·53
0·7	17·78	18·03	18·29	18·54	18·80	19·05	19·30	19·56	19·81	20·07
0·8	20·32	20·57	20·83	21·08	21·34	21·59	21·84	22·10	22·35	22·61
0·9	22·86	23·11	23·37	23·62	23·88	24·13	24·38	24·64	24·89	25·15
1·0	25·40	25·65	25·91	26·16	26·42	26·67	26·92	27·18	27·43	27·69
1·1	27·94	28·19	28·45	28·70	28·96	29·21	29·46	29·72	29·97	30·23
1·2	30·48	30·73	30·99	31·24	31·50	31·75	32·00	32·26	32·51	32·77
1·3	33·02	33·27	33·53	33·78	34·04	34·29	34·54	34·80	35·05	35·31
1·4	35·56	35·81	36·07	36·32	36·58	36·83	37·08	37·34	37·59	37·85
1·5	38·10	38·35	38·61	38·86	39·12	39·37	39·62	39·88	40·13	40·39
1·6	40·64	40·89	41·15	41·40	41·66	41·91	42·16	42·42	42·67	42·93
1·7	43·18	43·43	43·69	43·94	44·20	44·45	44·70	44·96	45·21	45·47
1·8	45·72	45·97	46·23	46·48	46·74	46·99	47·24	47·50	47·75	48·01
1·9	48·26	48·51	48·77	49·02	49·28	49·53	49·78	50·04	50·29	50·55
2·0	50·80	51·05	51·31	51·56	51·82	52·07	52·32	52·58	52·83	53·09

Table IV.—Wind Velocity.

Table IV.—Wind Velocity.

Miles per Hour to Metres per Second.

1 mile per hour=0·44704 metres per second.

Miles per Hour.	0	1	2	3	4	5	6	7	8	9
	Metres per Second.									
0	0·0	0·4	0·9	1·3	1·8	2·2	2·7	3·1	3·6	4·0
10	4·5	4·9	5·4	5·8	6·3	6·7	7·2	7·6	8·0	8·5
20	8·9	9·4	9·8	10·3	10·7	11·2	11·6	12·1	12·5	13·0
30	13·4	13·9	14·3	14·8	15·2	15·6	16·1	16·5	17·0	17·4
40	17·9	18·3	18·8	19·2	19·7	20·1	20·6	21·0	21·5	21·9
50	22·4	22·8	23·2	23·7	24·1	24·6	25·0	25·5	25·9	26·4
60	26·8	27·3	27·7	28·2	28·6	29·1	29·5	30·0	30·4	30·8
70	31·3	31·7	32·2	32·6	33·1	33·5	34·0	34·4	34·9	35·3
80	35·8	36·2	36·7	37·1	37·6	38·0	38·4	38·9	39·3	39·8
90	40·2	40·7	41·1	41·6	42·0	42·5	42·9	43·4	43·8	44·3
100	44·7	45·2	45·6	46·0	46·5	46·9	47·4	47·8	48·3	48·7
110	49·2	49·6	50·1	50·5	51·0	51·4	51·9	52·3	52·8	53·2
120	53·6	54·1	54·5	55·0	55·4	55·9	56·3	56·8	57·2	57·7
130	58·1	58·6	59·0	59·5	59·9	60·4	60·8	61·2	61·7	62·1
140	62·6	63·0	63·5	63·9	64·4	64·8	65·3	65·7	66·2	66·6

Climatic Summary—Richmond, Surrey—(*Kew Observatory*).

Lat. 51°28′, Long. 0°19′W., Altitude 10·4 m.

1. *Precipitation.*

—	Monthly Extremes of Rainfall.		Number of days with rain, &c., at the following hours:—				Number of days of precipitation within fixed limits.						Snow.	Snow lying.	Hail.	Thunderstorms.	Underground water above M.S.L.
	Greatest.	Least.	1 h.	7 h.	13 h.	18 h.	0	1 mm. or less.	1 mm.—5 mm.	6 mm.—15 mm.	16 mm.—25 mm.	Above 25 mm.					
	mm.	mm.															m.
January ..	124	11	3	3	2	3	14	9	5	3	1	—	3	Information not available.	½	$\frac{1}{10}$	3·66
February ..	105	2	2	3	2	3	14	7	6	2	—	—	2		½	$\frac{1}{10}$	3·49
March ..	100	6	3	3	4	4	13	9	7	2	—	—	3		1	½	3·66
April ..	101	1	2	2	2	3	17	6	5	2	—	—	1		1	1	3·19
May ..	104	5	2	2	2	2	18	5	6	2	—	—	$\frac{1}{10}$		1	1	2·69
June ..	183	6	2	3	3	2	17	5	4	3	—	—	—		⅓	2	2·37
July ..	124	12	1	2	2	2	19	4	5	3	—	—	—		⅓	3	2·05
August ..	165	12	1	2	3	3	16	6	6	4	—	—	—		⅓	2	2·04
September	129	11	2	2	2	2	16	8	4	2	—	—	—		⅕	1	1·94
October ..	151	15	3	3	3	3	10	10	6	4	1	—	$\frac{1}{10}$		⅕	⅓	1·87
November	101	12	4	3	2	3	12	9	5	4	—	—	⅓		⅕	$\frac{1}{10}$	2·00
December ..	162	10	3	3	4	4	12	8	7	4	—	—	2		⅕	$\frac{1}{10}$	2·90
The Year	970	423	28	31	31	34	178	86	66	35	2	—	12	—	6	11	2·66
Period ..	1866–1915.		20 years, 1896–1915.				25 years, 1891–1915.						39 years, 1877–1915.				2 years.

Period ..	1866–1915.	26 years, 1890–1915.	25 years, 1891–1915.	39 years, 1877–1915

Richmond (Surrey).—2. *Temperature.—Extremes and number of days in the month and year with max. and min. between fixed limits.*

—	Extremes recorded. High.	Extremes recorded. Low.	Normal monthly extremes. Max.	Normal monthly extremes. Min.	Maximum. 32°F. or less. 273a.	Maximum. 33°—41°F. 273—278a.	Maximum. 42°—59°F. 278—288a.	Maximum. 60°—77°F. 288—298a.	Maximum. Above 77°F. 298a.	Minimum. Below 15°F. 264a.	Minimum. 15°—32°F. 264—273a.	Minimum. 33°—41°F. 273—278a.	Minimum. 42°—59°F. 278—288a.	Minimum. Above 59°F. 288a.	Ground frosts.
	a.	a.	a.	a.											
January ...	286	260	285	268	2	10	19	—	—	$\frac{1}{10}$	11	14	5	—	17
February ...	90	61	85	69	$\frac{1}{2}$	8	20	—	—	$\frac{1}{10}$	9	14	5	—	16
March ...	92	65	89	70	—	4	25	1	—	—	9	16	6	—	16
April ...	300	70	92	72	—	$\frac{1}{5}$	23	7	—	—	2	17	11	—	13
May ...	302	72	97	75	—	—	13	18	$\frac{1}{3}$	—	$\frac{1}{2}$	8	22	—	6
June ...	304	76	99	79	—	—	3	25	2	—	—	1	29	$\frac{1}{2}$	1
July ...	305	79	301	81	—	—	$\frac{1}{2}$	25	5	—	—	—	28	3	—
August ...	308	78	300	81	—	—	$\frac{1}{2}$	28	3	—	—	—	28	3	—
September	306	74	297	77	—	—	5	24	1	—	—	3	27	1	2
October ...	297	69	92	73	—	$\frac{1}{10}$	22	9	—	—	2	10	19	—	7
November	90	66	87	70	$\frac{1}{10}$	3	26	$\frac{1}{2}$	—	—	6	14	11	—	14
December...	87	61	85	69	1	9	21	—	—	$\frac{1}{10}$	10	14	7	—	14
The Year ...	308	260	301	268	·4	34	178	137	12	—	49	111	198	7	106
Period ...	45 years, 1871–1915.														12 years, 1904–15.

Mean annual temperature 282·7a. Highest wet-bulb reading in 15 years 296·1a.

Richmond (Surrey).—3. *Pressure and Wind.*

—	Average change in 12 hrs.	Average gradient at 7 a.m.: To N. (Kew-Spurn Head).	Average gradient at 7 a.m.: To W. (Kew-Pembroke).	Number of gradients at 7 a.m.: For gales.	Number of gradients at 7 a.m.: For moderate winds.	Calm. 7	Calm. 13	Calm. 18	North 7	North 13	North 18	East. 7	East. 13	East. 18	South. 7	South. 13	South. 18	West. 7	West. 13	West. 18
	mb.	mb. per 100 k. +	+																	
January ..	4·4	1·1	0·6	9	17	8	5	5	4	5	4	3	4	5	7	7	8	9	10	9
February ..	4·5	0·9	0·5	10	15	7	2	4	4	5	4	3	3	4	8	9	8	7	9	8
March	3·6	0·9	0·2	10	16	8	1	4	5	8	6	3	3	3	8	9	9	7	10	9
April ..	3·1	0·4	0·3	5	20	8	1	2	6	7	7	3	4	5	6	8	7	7	10	9
May ..	2·6	0·3	0·1	4	20	7	1	3	9	10	9	4	4	5	5	8	8	6	8	6
June ..	2·2	0·3	0·1	2	19	7	1	2	7	8	7	4	4	5	6	9	9	6	8	7
July ...	2·4	0·6	0·1	3	21	9	1	3	5	6	6	3	3	4	5	9	8	9	12	10
August ..	2·7	0·7	0·2	4	21	10	2	4	4	5	5	2	3	4	8	10	11	7	11	8
September	2·3	0·6	0·3	4	19	12	2	7	5	7	6	4	5	5	5	8	7	4	8	5
October ..	3·5	0·8	0·3	7	20	12	3	8	4	6	4	4	5	5	7	10	9	4	7	5
November ..	4·0	0·8	0·5	9	16	10	4	6	5	6	6	3	4	3	6	7	7	6	9	8
December ..	4·8	1·2	0·6	12	17	7	4	5	3	3	3	3	4	3	11	11	12	7	9	7
The Year ..	3·3	0·7	0·3	79	221	105	27	53	61	76	67	39	46	52	82	105	103	79	111	91
Period ..	5 yrs.	1871–1905.		1908–1913.		20 years, 1896–1915.														

Richmond (Surrey).—4. *Humidity, Fog and Sunshine.*

—	Normal vapour pressure.			Normal Relative Humidity.			No. of days with Fog.			No. of days with bright Sunshine of specified duration.				
	At 7 h.	At 13 h.	At 18 h.	At 7 h.	At 13 h.	At 18 h.	At 7 h.	At 13 h.	At 18 h.	Nil.	0 to 3 h.	3 to 6 h.	6 to 9 h.	above 9 hrs.
	mb.	mb.	mb.	%	%	%								
January	6·6	7·1	6·9	87	80	84	3	3	1	15	9	6	1	—
February	6·5	7·1	7·0	85	75	80	2	1	1/5	9	10	6	3	—
March	6·8	7·4	7·4	86	68	74	1	—	1/5	5	11	7	6	2
April	7·9	8·3	8·3	84	62	66	1/2	—	—	3	8	6	7	6
May	9·8	10·0	10·0	81	61	63	—	—	—	2	6	6	6	11
June	11·9	12·5	12·5	80	60	62	1/2	—	—	2	6	5	7	10
July	13·6	13·7	14·0	81	59	61	1/2	—	—	1	7	6	7	10
August	13·6	13·7	14·0	85	61	65	1	—	—	1	7	7	7	9
September ...	11·8	12·6	12·7	89	65	73	3	—	1/5	3	8	7	8	4
October	9·6	10·6	10·5	91	73	83	9	1	2	7	11	7	6	1/2
November ...	8·0	8·8	8·6	90	79	86	4	1	1/2	12	10	6	2	—
December... ...	7·0	7·4	7·3	87	82	86	1	1/2	1	16	10	5	1/3	—
The Year ...	9·4	9·9	9·9	86	69	74	26	6	5	76	103	74	60	52
Period	25 years, 1886–1910.						5 years, 1911–15.			35 years, 1881–1915.				

The longest duration of recorded sunshine was 15·7 hrs. on 13th June, 1887.

CLIMATIC SUMMARY.—Paris (Parc St. Maur).

Latitude 48°49′N.; Longitude 2°29′E.; Altitude 50·3 m.; River datum 26·24 m.

1. *Precipitation.*

	Monthly Extremes of Rainfall.		Number of days with rain, &c., at fixed hours.			Number of days of precipitation within fixed limits.						Snow.	Thunderstorms.	Level of river • Pont d'Austerlitz.
	Greatest.	Least.	7 h.	13 h.	18 h.	Nil.	1 mm. or less.	1–5 mm.	6–15 mm.	16–25 mm.	Above 25 mm.			
	mm.	mm.												m.
January	74	5	3	2	2	17	6	6	2	$\frac{1}{5}$	—	6	$\frac{1}{5}$	1·5
February	74	2	2	2	2	15	5	6	2	$\frac{1}{5}$	—	5	$\frac{1}{2}$	1·8
March	86	10	2	2	2	17	5	7	2	$\frac{1}{5}$	$\frac{1}{10}$	6	1	1·7
April	101	1	2	2	2	18	5	5	2	$\frac{1}{3}$	$\frac{1}{10}$	2	2	1·7
May	95	7	2	2	1	17	5	7	2	$\frac{1}{2}$	$\frac{1}{10}$	$\frac{1}{2}$	4	1·4
June	107	9	1	1	1	18	4	5	2	$\frac{1}{2}$	$\frac{1}{3}$	—	6	1·0
July	96	18	1	1	1	19	4	4	3	$\frac{1}{2}$	$\frac{1}{10}$	—	5	0·7
August	84	13	1	1	2	19	4	5	2	$\frac{1}{2}$	$\frac{1}{3}$	—	5	0·9
September	118	—	1	1	2	19	3	5	2	$\frac{1}{2}$	$\frac{1}{10}$	—	3	0·9
October	159	5	2	2	2	17	4	6	3	$\frac{1}{2}$	$\frac{1}{5}$	$\frac{1}{10}$	1	1·0
November	114	10	2	2	2	17	5	5	3	$\frac{1}{10}$	$\frac{1}{10}$	2	$\frac{1}{3}$	1·0
December	71	16	2	2	2	16	7	6	2	$\frac{1}{3}$	—	3	$\frac{1}{5}$	1·4
The Year	750	418	21	20	21	209	57	67	27	4	1	22	28	1·25
Period	1891–1910.		1896–1910.			20 years, 1891–1910.						—	—	5 years.

Paris (Parc St. Maur).—2. *Temperature.*

Paris (Parc St. Maur).—2. *Temperature.*

—	Extremes recorded. High.	Extremes recorded. Low.	Normal monthly extremes. Max.	Normal monthly extremes. Min.	Maximum. 32°F. or less. 273a. or less.	Maximum. 34°F.—41°F. 274a.—278a.	Maximum. 43°F.—59°F. 279a.—288a.	Maximum. 61°F.—77°F. 289a.—298a.	Maximum. Above 77°F. Above 298a.	Minimum. Below 16°F. Below 264a.	Minimum. 16°F.—32°F. 264a.—273a.	Minimum. 34°F.—41°F. 274a.—278a.	Minimum. 43°F.—59°F. 279a.—288a.	Minimum. Above 59°F. Above 288a.	No. of days of ground frost.
	a.	a.	a.	a.											
January ..	289	256	285	265	4	10	17	1/10	—	1	14	12	4	—	16
February	94	58	87	66	1	7	19	1	—	1	13	9	5	—	13
March ...	99	62	92	68	1/10	3	23	5	—	—	10	14	7	—	11
April ...	301	70	97	72	—	—	15	15	1/2	—	3	13	14	—	3
May ...	305	72	301	75	—	—	7	21	3	—	1/3	7	24	1/3	1/5
June ...	308	75	303	79	—	—	1/2	22	7	—	—	1/2	28	2	—
July ...	311	79	305	81	—	—	—	19	12	—	—	—	24	7	—
August ...	309	78	305	80	—	—	—	21	10	—	—	—	26	5	—
September	309	74	301	77	—	—	1	24	5	—	—	2	26	2	—
October ...	299	68	295	72	—	—	14	17	1/3	—	2	8	21	1/3	3
November	95	58	89	69	1/2	4	23	3	—	—	8	11	11	—	6
December	91	47	86	65	3	9	19	1/5	—	1/2	13	12	6	—	14
Year ...	311	247	307	262	8	33	138	148	38	3	62	88	195	17	66
Period ..	30 years, 1873–1902.		50 years, 1851–1900.		20 years, 1891–1910.										

Paris (Parc St. Maur).—3. *Pressure and Wind.*

—	Average change in 12 hours, 9 to 9.	Average gradient at 7 h.				No. of gradients at 7 h.		Number of days in the month and year of wind direction in quadrants at 6 h., 12 h., 18 h.														
		To N.		To W.		For gale.	For moderate winds.	Calm.			North.			East.			South.			West.		
		M.S.L.	500 m.	M.S.L.	500 m.			6	12	18	6	12	18	6	12	18	6	12	18	6	12	18
	mb.	mb. per 100 k.		mb. per 100 k.																		
Jan.	3·6	+0·7	+0·6	+0·4	+0·2	11	11	1	1	½	7	7	8	6	6	6	8	8	8	10	10	10
Feb.	3·8	+0·6	+0·5	+0·4	+0·3	8	13	1	1	1	6	6	7	6	6	6	6	7	6	9	9	8
Mar.	3·2	+0·4	+0·4	+0·1	0·0	7	14	1	1	1	7	8	9	6	5	4	7	8	8	10	9	10
Apr.	2·8	+0·1	+0·2	−0·1	0·0	3	17	1	½	½	9	9	11	6	5	5	6	7	6	9	8	8
May	2·5	+0·1	+0·2	−0·1	0·0	2	15	1	½	⅓	11	11	12	6	5	5	6	7	5	7	8	8
June	2·1	+0·3	+0·2	−0·1	0·0	2	13	1	½	½	9	9	11	5	4	4	5	6	4	9	11	11
July	2·0	+0·3	+0·4	0·0	0·0	1	12	1	1	½	8	8	11	6	4	3	5	5	4	11	14	12
Aug.	2·4	+0·3	+0·3	0·0	0·0	1	12	1	1	1	7	6	8	5	4	4	6	7	6	12	13	13
Sept.	1·9	+0·3	+0·4	0·0	+0·1	2	11	1	1	1	7	7	9	6	6	6	7	7	6	9	9	8
Oct.	2·8	+0·6	+0·5	+0·3	+0·2	4	18	1	1	1	6	5	6	5	5	6	10	10	10	10	9	9
Nov.	3·4	+0·5	+0·6	+0·2	+0·2	6	13	1	2	1	6	5	6	7	7	7	8	8	8	8	9	8
Dec.	4·2	+0·9	+0·6	+0·5	+0·2	11	12	1	1	½	4	5	5	7	6	7	10	10	9	10	10	10
Year	2·9	+0·4	+0·3	+0·2	+0·1	58	161	12	11	8	88	85	102	70	60	62	82	92	79	113	118	114
Period	5 yrs. 1906–10.	50 years, 1851–1900.				5 years 1906–10.		20 years, 1890–1909.														

Paris (Parc St. Maur).—4. *Humidity and Fog.*

	Normal Vapour Pressure.			Normal Relative Humidity.			No. of days with Fog.		
	At 7 h.	At 13 h.	At 18 h.	At 7 h.	At 13 h.	At 18 h.	At 7 h.	At 13 h.	At 18 h.
	mb.	mb.	mb.	%	%	%			
January	6·3	6·7	6·7	90	77	84	2	1	1
February	6·4	6·7	6·8	90	69	77	2	$\frac{1}{2}$	$\frac{1}{5}$
March	6·9	7·1	7·1	88	59	66	2	$\frac{1}{10}$	—
April	8·3	7·7	7·9	80	50	56	$\frac{1}{5}$	—	—
May	10·5	10·1	10·3	79	52	58	$\frac{1}{3}$	—	—
June	13·5	13·1	13·3	79	55	61	$\frac{1}{10}$	$\frac{1}{10}$	—
July	14·9	14·5	14·7	81	55	60	—	—	—
August...	14·7	14·1	14·5	84	54	62	$\frac{1}{2}$	—	—
September	12·8	13·1	13·7	91	59	73	1	—	—
October	10·3	11·2	11·5	94	68	85	3	$\frac{1}{10}$	$\frac{1}{5}$
November	7·9	8·7	8·7	93	76	87	4	2	1
December	7·2	7·3	7·3	92	80	87	3	2	1
Year	9·5	10·0	10·3	87	63	71	19	5	4
Period	20 years, 1891–1910.			20 years, 1891–1910.			12 years, 1891–1902.		

Climatic Summary—Philippopoli.

Latitude 42°9′N.; Longitude 24°45′E.; Altitude 160 m.

1. *Precipitation.*

—	Monthly Extremes of Rainfall.		Number of days in the month and year of precipitation within fixed limits.							Number of days of		
	Greatest.	Least.	0.	Under 0·1 mm.	0·1 — 1·0 mm.	1·1 — 5·9 mm.	6·0 — 15·9 mm.	16·0 — 25·0 mm.	Above 25·0 mm.	Snow.	Snow lying.	Thunderstorms.
	mm.	mm.										
January ...	155	3	22	1	2	3	2	⅓	½	6	16	—
February ...	96	10	17½	2	2	4	2	½	1/10	5	8	⅕
March ...	65	11	21½	1	3	3	2	½	—	3	2	—
April ...	117	8	20	2	2	3	2	½	½	½	—	2
May ...	90	8	18½	3	4	3	2	1/10	⅓	—	—	5
June ...	201	25	14½	2	4	6	2	1	½	—	—	8
July ...	96	8	23½	2	1	3	1	1/10	½	—	—	4
August ...	102	0	24½	2	1	2	1	1/10	½	—	—	4
September	100	1	22	2	2	2	1	½	⅕	—	—	2
October ...	89	6	22½	1	2	3	2	⅕	⅕	—	—	½
November	121	18	18	2	3	4	2	½	½	2	1	—
December...	84	4	21½	1	3	4	1	⅓	⅕	2	4	—
The Year	860	338	246	21	29	40	20	5	4	19	31	26
Period ...	11 years, 1900–10.											

Philippopoli.—2. *Temperature.*

—	Extremes recorded.		Normal monthly extremes.		Number of days in the month and year with max. and min. between fixed limits.										Frost.
					Maximum.					Minimum.					
	High.	Low.	Max.	Min.	32°F. or less. 273a. or less.	33°F.—41°F. 274—278a.	42°F.—59°F. 279—288a.	60°F.—77°F. 289—298a.	Above 77°F. Above 298a.	Below 15°F. Below 264a.	15°F.—32°F. 264—273a.	33°F.—41°F. 274—278a.	42°F.—59°F. 279—288a.	Above 59°F. Above 288a.	Min.=32°F. 273a.
	a.	a.	a.	a.											
January ...	289	258	285	261	10	12	9	—	—	5	21	5	—	—	26
February ...	295	254	288	266	4	9	13	2	—	2	13	11	2	—	15
March ...	297	265	292	271	—	5	18	8	—	—	9	16	6	—	9
April ...	302	272	299	274	—	—	9	19	2	—	1	10	19	—	1
May ...	309	276	303	280	—	—	1	18	12	—	—	1	26	4	—
June ...	309	281	306	284	—	—	—	7	23	—	—	—	12	18	—
July ...	310	284	308	286	—	—	—	2	29	—	—	—	4	27	—
August ...	311	283	309	285	—	—	—	3	28	—	—	—	6	25	—
September	307	275	304	280	—	—	1	15	14	—	—	1	21	8	—
October ...	306	271	300	274	—	—	6	22	3	—	1	4	25	1	1
November	295	261	292	269	1	3	21	5	—	—	8	11	11	—	8
December...	293	254	287	266	3	8	19	1	—	1	15	13	2	—	16
The Year ...	311	254	309	261	18	37	97	102	111	8	68	72	134	83	76
Period ...	11 years, 1900–10.														

Philippopoli.—3. *Wind.*

—	Number of days in the month and year of wind directions in quadrants at 7 h., 14 h., 21 h.														
	Calm.			North.			East.			South.			West.		
	7	14	21	7	14	21	7	14	21	7	14	21	7	14	21
Jan.	7	6	10	2	5	1	5	5	6	4	2	3	13	13	11
Feb.	5	5	10	2	2	1	7	10	6	5	3	3	9	8	8
March	6	5	9	1	3	1	10	14	10	6	3	4	8	6	7
April	7	4	10	1	4	1	8	15	8	5	2	4	9	5	7
May	9	14	13	2	4	1	6	15	6	3	3	3	11	5	8
June	7	5	13	3	5	3	4	9	4	4	5	3	12	6	7
July	9	6	14	3	5	2	2	11	4	4	3	6	13	6	5
Aug.	8	4	12	1	4	2	4	12	7	6	5	5	12	6	5
Sept.	8	4	11	1	3	2	5	15	9	7	4	4	9	4	4
Oct.	6	7	9	2	3	1	6	9	6	6	4	5	11	8	10
Nov.	7	5	10	1	3	1	8	9	7	6	5	5	8	8	7
Dec.	7	7	8	2	5	1	6	6	6	4	3	5	12	10	11
Year	86	72	129	21	46	17	71	130	79	60	42	50	127	85	90
Period	6 years, 1900-1905.														

Philippopoli.—4. *Humidity and Fog.*

	Normal Vapour Pressure.			Normal relative Humidity.			No. of days with fog.		
	At 7 h.	At 14 h.	At 21 h.	At 7 h.	At 14 h.	At 21 h.	At 7 h.	At 14 h.	At 21 h.
	mb.	mb.	mb.	%	%	%			
January ...	4·5	5·2	4·9	85	71	81	4	½	2
February ...	5·7	6·5	6·4	87	70	81	4	⅕	1
March ...	6·5	7·3	7·3	85	60	75	3	—	⅕
April ...	8·5	9·0	9·5	80	51	69	½	—	—
May ...	12·4	12·8	13·5	79	50	70	⅕	—	—
June ...	15·5	15·6	16·4	77	50	69	⅕	—	—
July ...	16·0	16·4	16·8	71	44	60	—	—	—
August ...	15·5	15·7	15·7	74	41	58	—	—	—
September ...	12·8	13·7	13·6	81	47	67	⅕	—	—
October ...	10·4	11·9	11·5	87	58	76	2	—	$\frac{1}{10}$
November ...	7·5	8·3	8·1	87	68	83	3	⅕	1
December ...	6·0	6·8	6·0	87	73	83	6	1	2
Year ...	10·1	10·8	10·8	82	57	73	23	2	6
Period ...	11 years, 1900–10.								

Climatic Summary.—Babylon.

Latitude, 32°30′N.; longitude, 44°20′E.; altitude about 30 m.

1. *Precipitation.*

	Monthly Extremes of Rainfall.		Number of days in the month and year of precipitation within fixed limits.					No. of days of		Approximate variation of river level.	
	Greatest.	Least.	0.	1 mm. or less.	1 mm.—5 mm.	5 mm.—10 mm.	10 mm. and above.	Snow.	Thunderstorms.	Tigris, near Bagdad.	Euphrates, near Babylon.
	mm.	mm.								m.	m.
January ...	36	2	21	6	2	1	1	Very rare.	1	2·0	1·0
February ...	15	5	19	6	2	1	—		2	3·0	2·0
March ...	66	4	22	6	2	—	1		2	5·0	3·0
April... ...	13	2	23	6	1	1/5	—		5	6·0	3·5
May	1	0	25	6	1/5	—	—		5	5·5	3·3
June	0	0	28	2	—	—	—		1	3·5	2·0
July	0	0	30	1/5	—	—	—		—	2·0	1·3
August ...	0	0	31	0	—	—	—		—	1·0	1·0
September ...	0	0	29	1/2	—	—	—		—	0·0	0·0
October ...	42	0	26	4	1/2	—	—		1	0·0	0·0
November ...	18	0	24	4	1	—	1		2	1·5	1·0
December ...	52	3	22	6	2	1/2	1/2		2	1·0	0·8
The Year ...	156	53	300	47	11	3	4		21	2·5	1·7
Period ...	5½ years, June, 1907—December, 1912.									Uncertain.	

Babylon.—2. *Temperature.*

	Extremes recorded.		Normal monthly extremes.	
	High.	Low.	Max.	Min.
	a.	a.	a.	a.
January	297	267	294	270
February	301	270	298	272
March	308	274	304	277
April	314	278	311	281
May	319	287	316	288
June	322	289	319	291
July	322	289	320	294
August	323	290	320	293
September	320	287	319	289
October	313	281	312	283
November	306	270	303	275
December	300	266	296	270
The Year	323	266	320	270
Period	5½ years, June, 1907--December, 1912.			

Babylon.—3. *Wind.*

—	Number of days in the month and year of wind directions in quadrants at 7 h., 14 h. and 20 h. 30 m. (noted in the table as 21).														
	Calm.			North.			East.			South.			West.		
	7	14	21	7	14	21	7	14	21	7	14	21	7	14	21
January ...	0	0	2	7	11	9	5	4	7	6	6	6	13	10	7
February ...	1	0	1	6	10	10	6	4	7	5	6	5	10	8	5
March ...	1	0	2	8	11	9	6	4	7	6	7	6	10	9	7
April ...	1	1	2	9	11	10	5	3	8	5	5	5	10	10	5
May ...	1	0	2	10	12	13	5	3	6	4	5	4	11	11	6
June ...	0	0	2	14	16	13	1	1	2	1	2	2	14	11	11
July ...	0	0	2	14	16	11	1	0	2	1	1	2	15	14	14
August ...	0	0	3	12	15	12	1	1	2	1	1	2	17	14	12
September ...	1	1	4	11	14	12	2	1	3	1	2	2	16	12	9
October ...	1	0	4	10	13	11	4	3	5	4	5	4	12	10	7
November ...	2	0	3	7	12	9	4	3	5	3	4	4	14	11	9
December ...	1	0	3	8	12	9	3	3	5	4	5	4	15	11	10
The Year ...	9	2	30	116	153	128	43	30	59	41	49	46	157	131	102
Period ...	5½ years, June, 1907–December, 1912.														

Babylon. 4.—*Humidity.*

	Normal Vapour-Pressure.			Normal Relative Humidity.		
	At 7h.	At 14h.	At 20·5h.	At 7h.	At 14h.	At 20·5h
	mb	mb	mb	%	%	%
January ...	6·6	7·4	7·4	84	49	69
February ...	7·1	7·2	7·3	73	40	53
March	9·9	8·0	8·2	66	30	44
April	11·5	9·6	10·3	58	27	40
May	13·9	12·2	12·5	47	22	34
June	12·9	10·9	12·0	36	17	26
July	13·0	10·8	12·8	33	13	25
August ...	11·8	10·5	11·2	32	13	22
September ...	10·7	9·5	10·0	38	13	23
October ...	9·9	9·9	9·8	49	21	34
November ...	8·6	9·4	9·6	68	34	50
December ...	7·6	8·7	8·5	84	48	68
The Year ...	10·3	9·5	10·0	56	27	41
Period ...	$5\frac{1}{2}$ years June 1907—December 1912.					

Climatic Summary. Helwan, Egypt.—

Latitude, 29° 51′ N.; Longitude, 31° 20′ E.; Altitude, 115·7 m.

1. *Precipitation.*

—	Monthly Extremes of Rainfall.		No. of days of precipitation within fixed limits.						Gauge reading of Nile at Roda (Cairo).
	Greatest.	Least.	Trace.	Less than 1·0 mm.	1·1 mm. —5·9 mm.	6·0 mm. —15·9 mm.	16·0 mm. —25 mm.	Above 25 mm.	
	mm.	mm.							m.
Jan.	37	1·4	4	1	2	1/3	1/10	—	14·9
Feb.	25	0	2	1	1	—	1/10	—	14·6
March	25	0	2	1/2	1/3	1/3	—	—	14·3
April	50	0	3	1/3	1/5	1/10	—	1/5	14·0
May	10	0	2	—	—	1/10	—	—	13·8
June	0	0	1/5	—	—	—	—	—	13·8
July	0	0	—	—	—	—	—	—	14·4
Aug.	0	0	—	—	—	—	—	—	17·4
Sept.	0	0	—	—	—	—	—	—	18·9
Oct.	3	0	2	1/10	1/10	—	—	—	18·9
Nov.	13	0	2	1/2	1/2	1/10	—	—	17·1
Dec.	19	0	4	1/2	1	1/10	—	—	15·6
Year	91	5	21	4	5	1	1/5	1/5	15·6
Period	9 years, 1904–12.								38 years, 1873–1910

Helwan. 2.—*Temperature.*

—	Extremes recorded.		Normal Monthly Extremes.		Number of days in the month and year with max. and min. between fixed limits.					
					Maximum.			Minimum.		
	High.	Low.	Maximum.	Minimum.	42°F.—60°F. 279a—288a.	60°F.—77°F. 289a—298a.	Above 77°F. Above 298a.	33°F.—42°F. 274a—278a.	42°F.—59°F. 279a—288a.	Above 59°F. Above 288a.
	a	a	a	a						
January... ...	302	275	299	276	6	24	1	6	25	$\frac{1}{2}$
February ...	302	276	300	277	2	24	3	3	24	$\frac{1}{5}$
March	309	276	304	279	1	22	8	1	28	2
April	315	279	311	281	—	9	21	—	21	9
May	317	284	314	285	—	1	30	—	7	24
June	319	286	315	289	—	—	30	—	$\frac{1}{9}$	30
July	315	289	313	291	—	—	31	—	—	31
August	313	290	312	292	—	—	31	—	—	31
September ...	314	287	309	290	—	—	30	—	—	30
October	314	284	309	287	—	2	29	—	3	29
November ...	307	279	303	282	—	16	14	—	20	10
December ...	302	274	297	279	2	29	$\frac{1}{2}$	2	28	1
The Year ...	319	274	315	276	11	127	229	12	156	198
Period ...	9 years, 1904–12.									

Helwan. 3.—*Wind.*

—	Number of days in the month and year of wind direction in quadrants at 8 h., 14 h., 20 h.														
	Calm.			North.			East.			South.			West.		
	8	14	20	8	14	20	8	14	20	8	14	20	8	14	20
Jan.	½	0	0	8	13	15	13	4	10	8	5	4	2	9	3
Feb.	1	0	½	4	6	12	11	2	6	9	5	5	3	15	5
March	0	0	0	13	15	16	11	5	10	5	3	3	2	8	2
April	0	½	0	14	14	18	6	4	10	6	3	2	4	10	1
May	½	½	½	18	19	18	6	3	10	3	2	1	4	7	2
June	1	½	0	16	19	22	8	3	7	2	½	0	3	7	2
July	½	0	0	24	23	27	3	1	1	½	0	0	3	7	3
Aug.	1	0	0	25	22	29	2	1	1	0	0	½	4	8	1
Sept.	1	0	0	22	24	26	5	2	4	0	0	0	2	5	0
Oct.	0	0	0	16	25	21	11	4	10	1	0	0	3	2	0
Nov.	0	0	0	11	12	16	12	4	8	6	5	4	1	9	2
Dec.	0	0	0	8	9	12	12	2	10	10	8	5	2	12	4
Year	6	2	1	179	201	232	100	35	87	51	32	25	33	99	25
Period	3 years, 1906–1908.														

Helwan.—4. *Humidity, Fog and Sunshine.*

—	Normal Vapour Pressure.			Normal relative Humidity.			No. of days with Fog.*	No of days with Bright Sunshine of specified duration.				
	At 8 h.	At 14 h.	At 20 h.	At 8 h.	At 14 h.	At 20 h.	At 8 h.	Nil.	0 to 3 h.	3 to 6 h.	6 to 9 h.	Above 9 h.
	mb.	mb.	mb.	%	%	%						
January ...	8·0	7·9	8·1	69	42	56	5	1	4	7	15	4
February ...	8·0	7·2	7·6	64	34	48	3	1	3	4	10	10
March ...	9·3	7·1	8·0	63	29	43	1	1	3	4	10	13
April ...	10·7	7·6	8·7	55	23	36	—	½	2	3	6	19
May ...	12·4	8·1	10·1	50	20	32	—	—	1	2	2	26
June ...	15·6	10·0	12·0	55	21	33	—	—	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{3}$	30
July ...	19·3	12·0	14·3	65	24	34	1	—	—	—	$\frac{1}{5}$	31†
August ...	20·5	13·1	16·0	69	27	40	—	—	—	—	—	31
September	18·9	11·6	16·3	68	30	48	—	—	—	—	3	27
October ...	19·3	12·0	14·4	67	33	51	1	—	2	1	16	12
November	12·5	10·6	11·7	68	37	54	3	—‡	1	3	19	7
December...	9·5	9·3	9·5	70	44	58	4	⅓	3	6	18	3
The Year ...	13·7	9·7	11·4	64	30	44	18	4	19	30	100	213
Period ...	9 years, 1904–12.						7 years, 1904–10.	9 years, 1904–12.				

*All fogs, &c., were observed at 8 a.m. and on an average only 1·7 per annum continued to 11 a.m.
† In 9 years there was one day with less than 9 hours Sunshine.
‡ In 9 years there was one day with no Sunshine.

Climatic Summary—Dar es Salam, East Africa.

Latitude, 6°49′S.; Longitude, 39°18′E.; Altitude, 7·6 m.; Lake datum, 3723·55 ft.

1. *Precipitation.*

—	Monthly Extremes of Rainfall.		Number of days in the month and year of precipitation within fixed limits.							Thunderstorms.	Average level of Lake Victoria at Port Florence.
	Greatest.	Least.	0.	< 0·3 mm.	0·3 to 0·9 mm.	1·0 to 4·9 mm.	5·0 to 9·9 mm.	10·0 to 24·9 mm.	> 25 mm.		
	mm.	mm.									Inches.
January ...	260	1·3	20	2	2	3	2	2	⅓	2	35·6
February ...	153	1·1	19	3	1	2	1	1	1	2	35·9
March ...	266	41	17	4	2	2	2	3	1	4	36·4
April ...	604	176	7	2	3	5	4	4	5	4	38·7
May ...	291	6·2	14	2	2	6	2	3	2	1	43·4
June ...	116	3·3	20	3	2	3	1	1	—	—	43·9
July ...	86	16	20	4	2	2	2	1	⅓	—	40·1
August ...	108	0	20	4	2	3	2	½	—	—	37·3
September	41	1·5	19	4	3	2	2	½	—	—	35·2
October ...	120	12	21	4	3	2	0	1	—	—	33·8
November	225	17	19	3	2	3	2	1	⅓	1	33·5
December...	246	7	18	3	3	2	2	3	⅓	2	35·1
Year ...	1414	719	214	38	27	35	22	21	10	16	37·4
Period ...	10 years, 1903–12.									17 years 1896–12.	21 years.

Dar es Salam, East Africa.—2. *Temperature.*

—	Extremes recorded.		Normal Monthly Extremes.		Number of days in month and year with max. and min. between fixed limits.			
					Maximum.		Minimum.	
	High.	Low.	Max.	Min.	61°F.—77°F. 289a.—298a.	78°F.—91°F. 298a.—306a.	61°F.—77°F. 289a.—298a.	78°F.—91°F. 299a.—306a.
	a	a	a	a				
January ...	305	294	304	295	—	31	15	16
February ...	305	294	304	295	—	28	17	11
March ...	305	294	305	295	—	31	26	5
April... ...	306	293	306	294	1	29	30	0
May	306	292	303	292	1	30	31	0
June	304	288	302	291	1	29	30	0
July	304	289	302	290	1	30	31	0
August ...	304	289	303	290	—	31	31	0
September ...	304	290	303	291	—	30	30	0
October ...	305	290	304	291	—	31	31	0
November ...	305	293	304	293	—	30	27	3
December ...	305	288	304	295	—	31	19	12
Year ...	306	288	306	290	4	361	318	47
Period ...	17 years, 1896–1912.		10 years, 1903–12.					

Dar es Salam, East Africa.—3. *Wind.*

—	No. of days in the month and year of wind-direction in quadrants at 7 h., 14 h., 21 h.														
	Calm.			North.			East.			South.			West.		
	7	14	21	7	14	21	7	14	21	7	14	21	7	14	21
Jan.	2	0	1	15	15	12	6	15	14	4	1	2	4	0	2
Feb.	2	0	0	13	14	8	4	13	18	4	0	1	5	1	1
March	3	1	2	4	8	2	2	18	16	11	3	8	11	1	3
April	2	2	3	0	1	0	0	12	4	15	13	17	13	2	6
May	2	0	2	0	0	0	0	11	2	16	17	22	13	2	5
June	1	0	1	0	0	0	0	8	3	16	20	19	13	2	7
July	1	0	2	0	0	0	0	10	3	18	20	22	12	1	4
Aug.	2	0	0	0	0	0	0	21	8	16	10	21	13	0	2
Sept.	2	0	2	0	0	0	0	22	10	16	5	18	12	3	0
Oct.	3	0	2	0	0	0	1	29	14	16	2	15	11	0	0
Nov.	4	1	1	2	2	1	4	27	20	12	1	8	8	0	0
Dec.	4	1	1	9	7	4	5	21	22	6	1	3	7	1	1
Year	28	5	17	43	47	27	22	207	134	150	93	156	122	13	31
Period	10 years, 1903–12.														

Dar es Salam, East Africa.—4. *Humidity and Fog.*

—	Normal Vapour Pressure.			Normal Relative Humidity.			No. of days with fog.
	At 7 h.	At 14 h.	At 21 h.	At 7 h.	At 14 h.	At 21 h.	
	mb.	mb.	mb.	%	%	%	
January ...	28·5	29·3	29·2	85	74	82	1
February ...	27·9	29·2	28·9	86	72	81	1
March ...	27·9	29·6	29·3	90	74	84	2
April ...	27·2	28·5	28·3	94	78	90	5
May ...	25·1	25·5	26·0	93	70	88	3
June ...	22·3	22·0	23·1	92	62	85	5
July ...	21·6	21·2	22·9	93	61	85	3
August ...	21·9	22·4	22·8	93	65	84	5
September...	22·5	24·1	23·4	91	69	84	3
October ...	24·4	25·9	24·9	89	70	83	1
November...	27·9	27·9	27·4	88	73	84	0
December ...	28·3	29·1	28·9	87	75	83	1
Year ...	25·5	26·2	26·3	90	70	84	30
Period ...	12 years, 1901–12.						11 years.

NOTES ON THE CLIMATOLOGICAL TABLES.

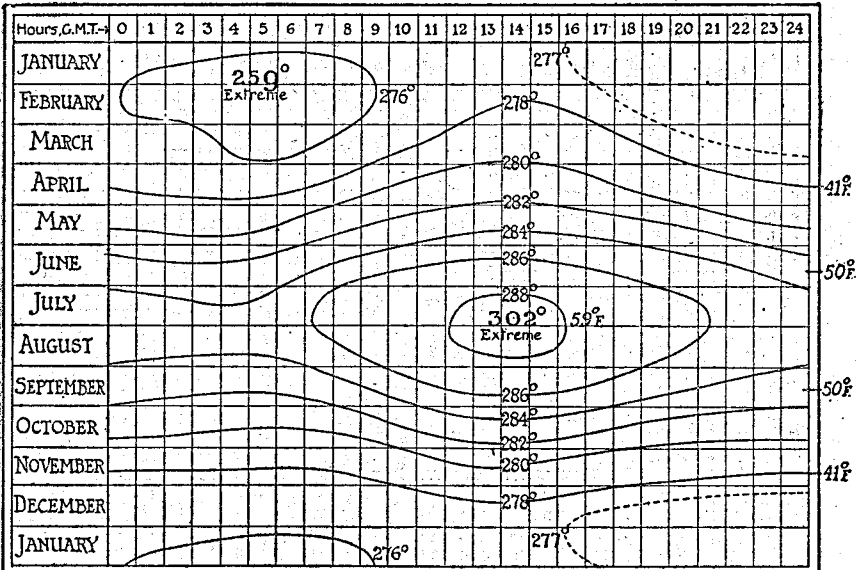
1. In table 1, for each station, the figures set against "The Year" at the foot of the columns for "Monthly extremes of Rainfall" give the greatest and least of the totals for the several *years* of the period indicated.

2. In tables 3 for KEW and PARIS (*see* pages 66 and 70), the figures headed "No. of gradients at 7 a.m." were obtained by measurements of the steepness of the barometric gradient on daily synoptic Charts. The results given in the tables show, therefore, the prevalence of GEOSTROPHIC winds, computed from the gradient without any allowance for the curvature of the path of the air. They are generally in good agreement with the actual winds blowing at a height of about 1500 feet above the surface of the ground. Owing to land friction, the prevalence of surface winds of the strengths indicated by the gradients would be appreciably smaller than is shown by the figures in the tables.

CLIMATIC CHARTS.

The eight charts which follow are reproduced from the book of normals of the British stations of the Meteorological Office to show the general climatic conditions of the various parts of the British Isles in winter and summer.

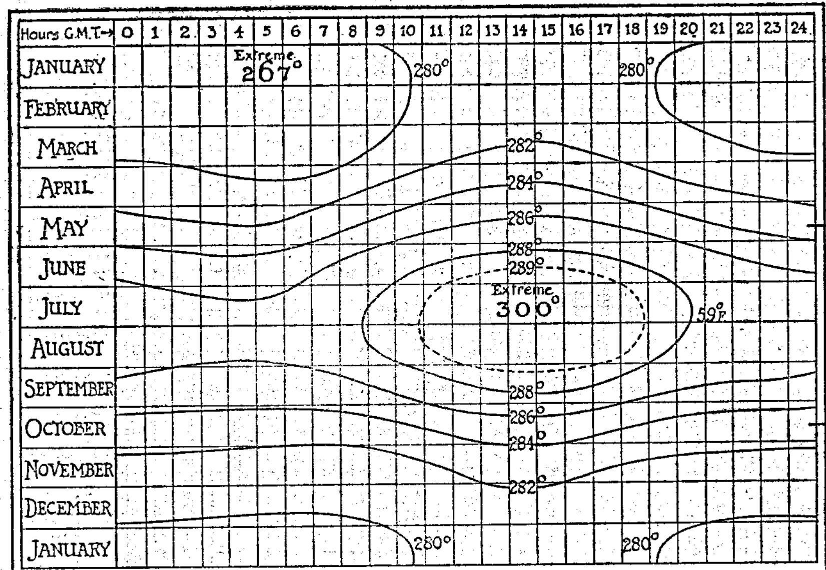
Climatic Diagram No. 1.



Mean Temperature at ABERDEEN for 40 Years, 1871-1910.
Isopleths showing Seasonal and Diurnal Variation.

The extremes recorded during the 40 years are noted within the Maximum and Minimum curves.

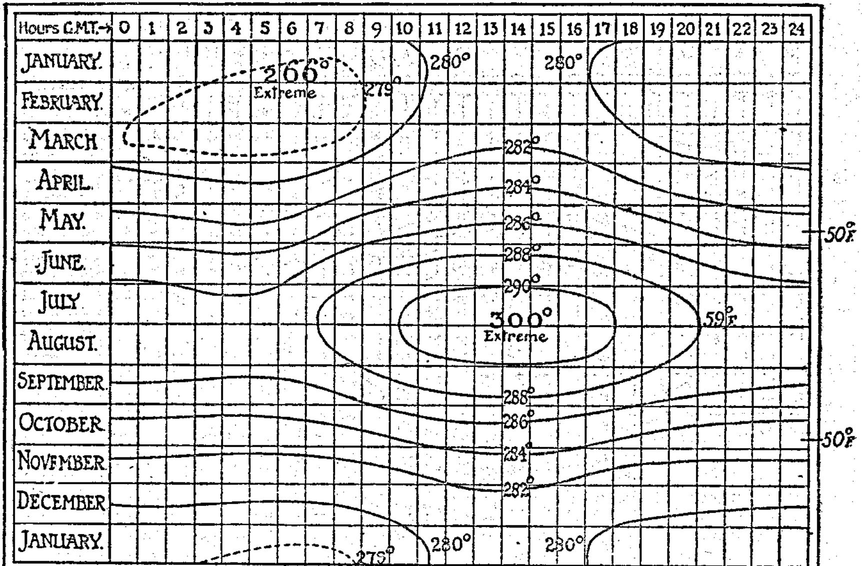
CLIMATIC DIAGRAM NO. 2.



Mean Temperature at VALENCIA for 40 Years, 1871~1910.
Isopleths showing Seasonal and Diurnal Variation.

The extremes recorded during the 40 years are noted within the Maximum and Minimum curves.

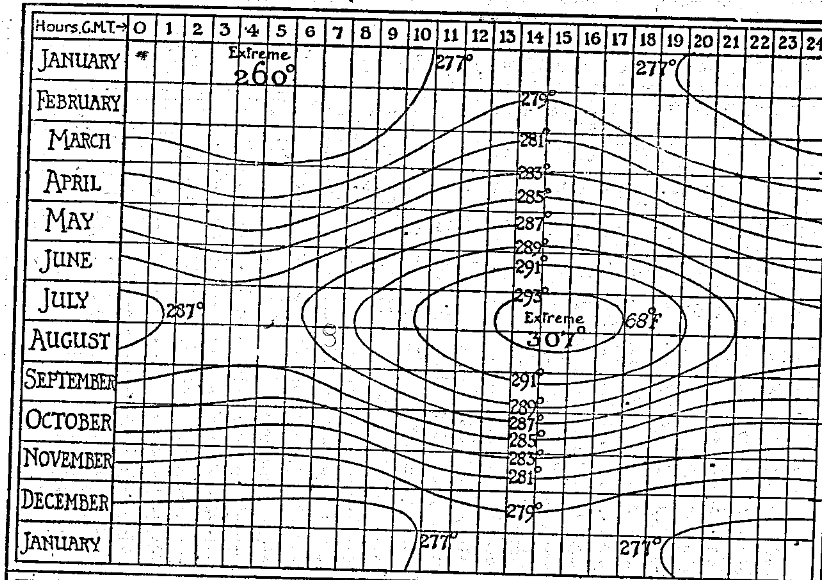
Climatic Diagram No. 3.



Mean Temperature at FALMOUTH for 40 Years, 1871–1910.
Isopleths showing Seasonal and Diurnal Variation.

The extremes recorded during the 40 years are noted within the Maximum and Minimum curves

CLIMATIC DIAGRAM NO. 4



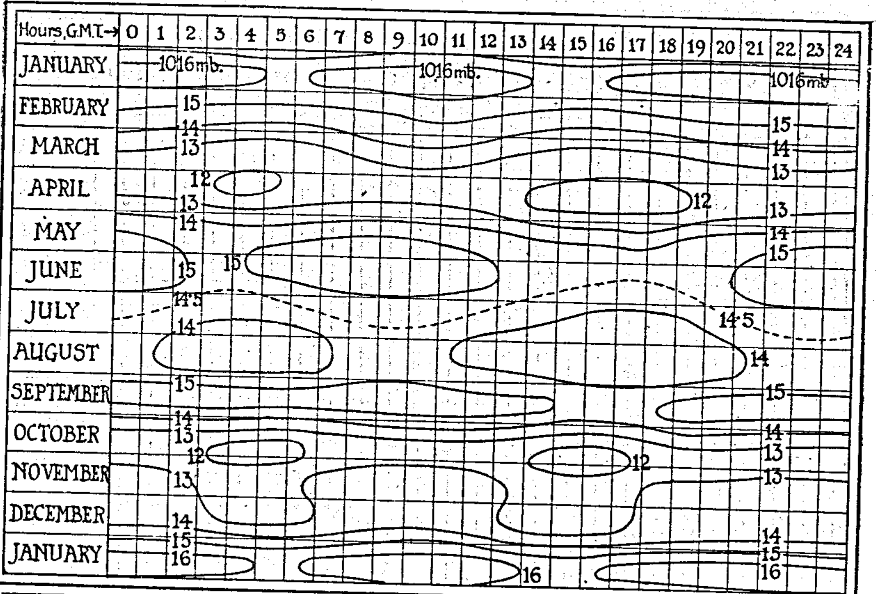
Mean Temperature at KEW for 40 Years, 1871-1910.
Isopleths showing Seasonal and Diurnal Variation.

The extremes recorded during the 40 years are noted within the Maximum and Minimum curves.

CLIMATIC DIAGRAM NO. 5.

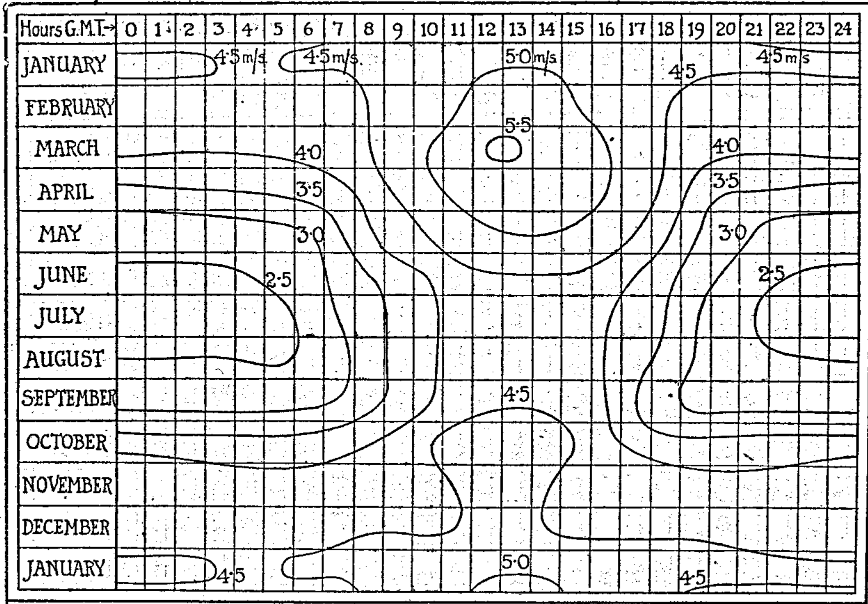
...are noted within the Maximum and Minimum curves.

CLIMATIC DIAGRAM NO. 5.



Mean Barometric Pressure at KEW for 40 Years, 1871–1910
Isopleths showing Seasonal and Diurnal Variation
Values are for Station Level Height above Mean Sea Level, 104 metres.

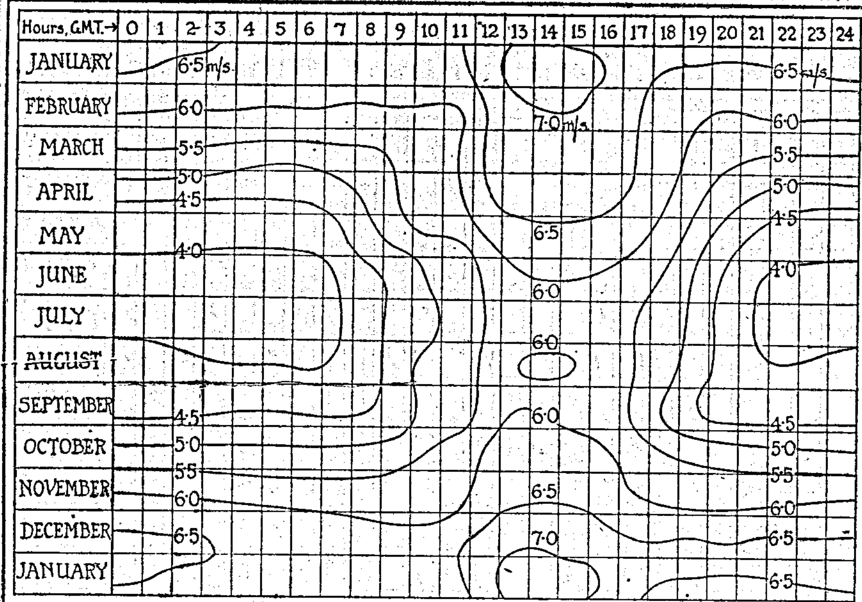
CLIMATIC DIAGRAM No. 6.



Mean Velocity of Wind at ABERDEEN for 30 Years 1881–1910.
Isopleths showing Seasonal and Diurnal Variation.

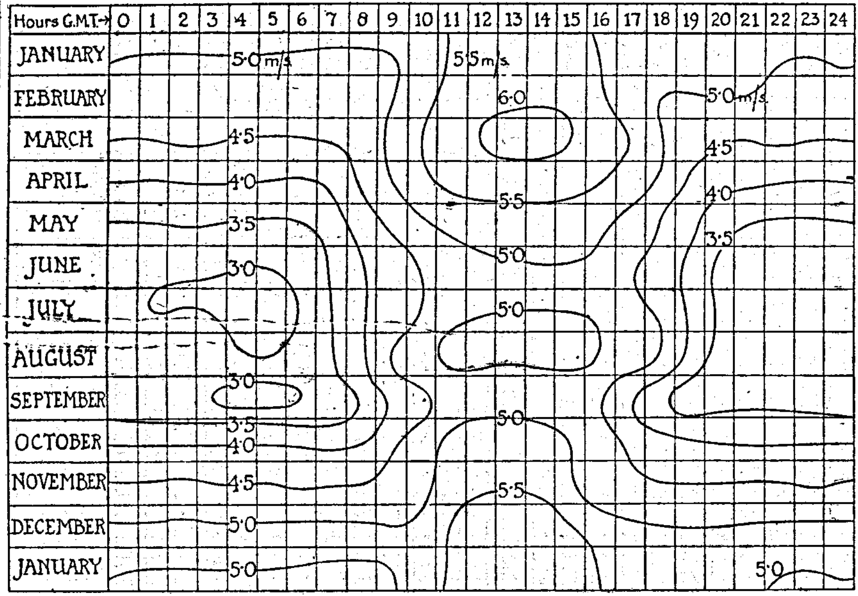
At Aberdeen the velocity of the Recorded Wind bears to the Geostrophic Wind a mean ratio of 25·2 per cent mean ratio of 25·2 per cent

Climatic Diagram No. 7.



*Mean Velocity of Wind at VALENCIA for 30 Years 1881-1910.
Isopleths showing Seasonal and Diurnal Variation.

At Valencia the velocity of the Recorded Wind bears to the Geostrophic Wind a mean ratio of 34·3 per cent.



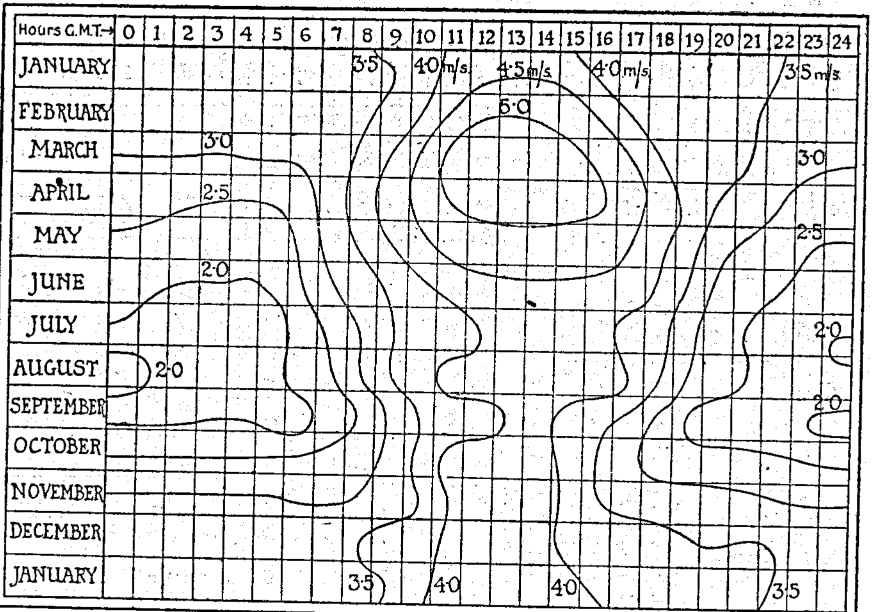
Mean Velocity of Wind at FALMOUTH for 30 Years 1881–1910.
Isopleths showing Seasonal and Diurnal Variation.

At Falmouth the Velocity of the Recorded Wind bears to the Geostrophic Wind a mean ratio of about 30 per cent.

CLIMATIC DIAGRAM No. 9.

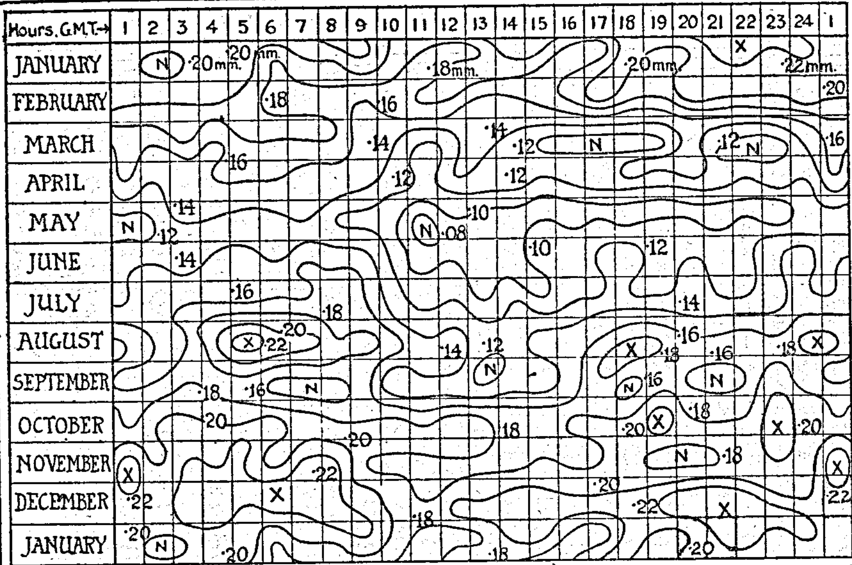
... the Velocity of the Recorded Wind bears to the Geostrophic Wind a mean ratio of about 30 per cent.

CLIMATIC DIAGRAM No. 9.



Mean Velocity of Wind at KEW for 30 Years 1881·1910.
Isopleths showing Seasonal and Diurnal Variation.

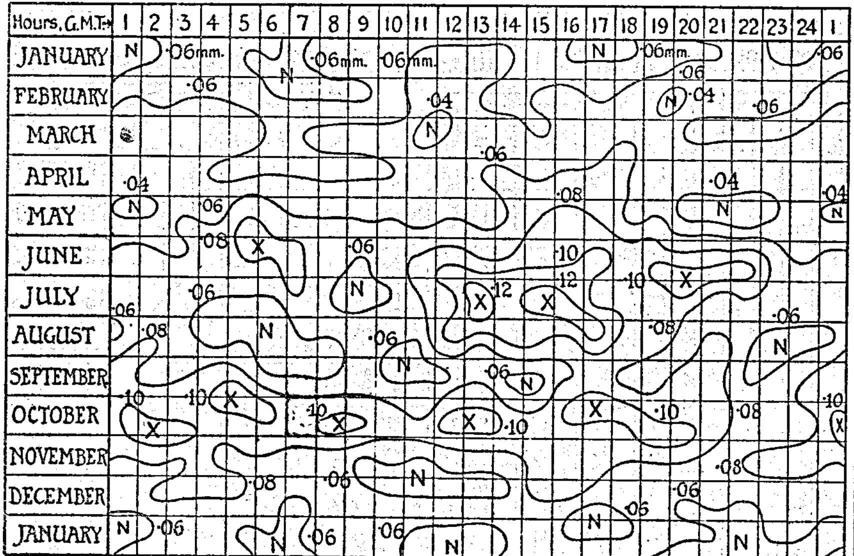
CLIMATIC DIAGRAM No. 10.



Normal Hourly Rainfall at VALENCIA for 40 years 1871~1910.
Isopleths showing Seasonal and Diurnal Variation.
Height of Station above Mean Sea Level 13·7 metres.
The closed curves surrounding a maximum are marked X, those surrounding a minimum, N.

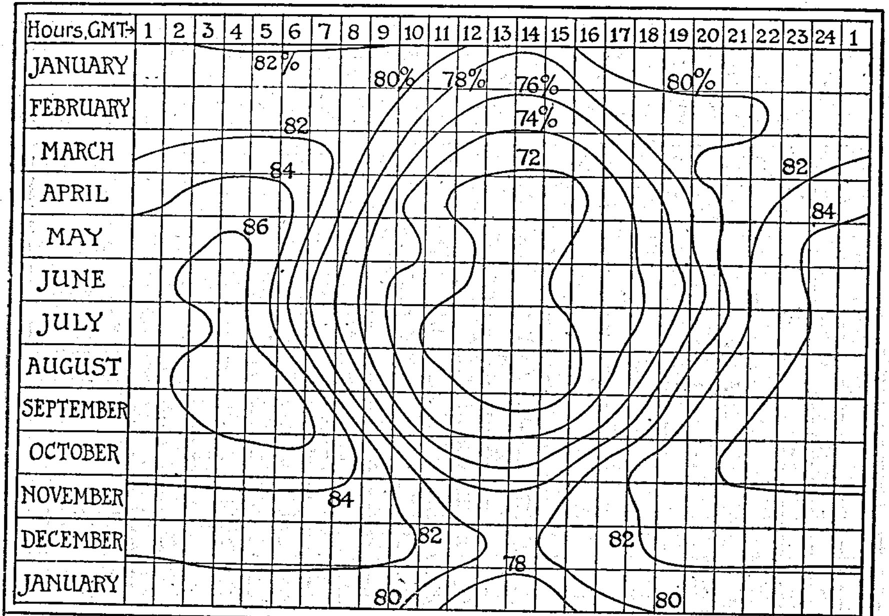
CLIMATIC DIAGRAM No. 11.

Climatic Diagram No. 11.



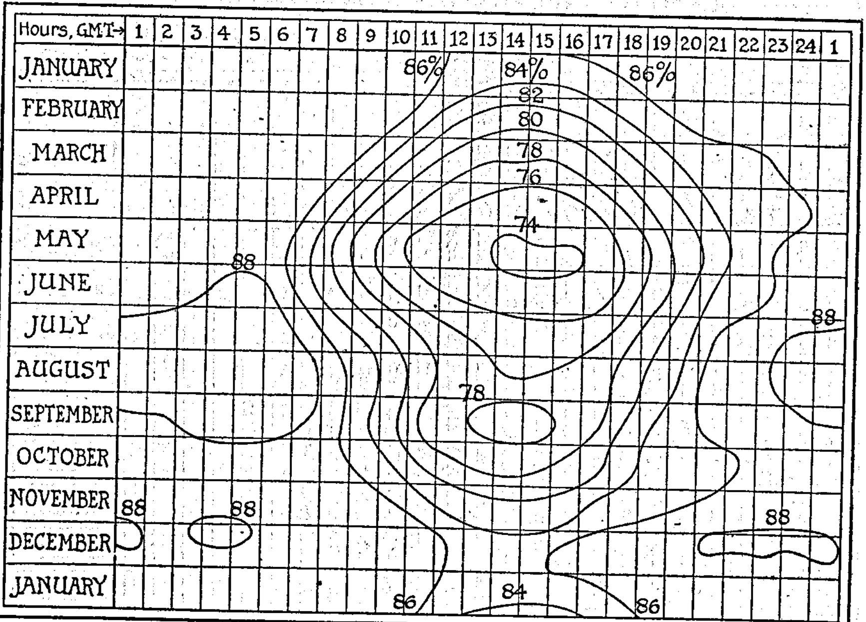
Normal Hourly Rainfall at KEW for 40 years, 1871–1910.
Isopleths showing Seasonal and Diurnal Variation.
Height of Station above Mean Sea Level, 10·4 metres.
The closed curves surrounding a maximum are marked X, those surrounding a minimum, N.

CLIMATIC DIAGRAM NO. 12.



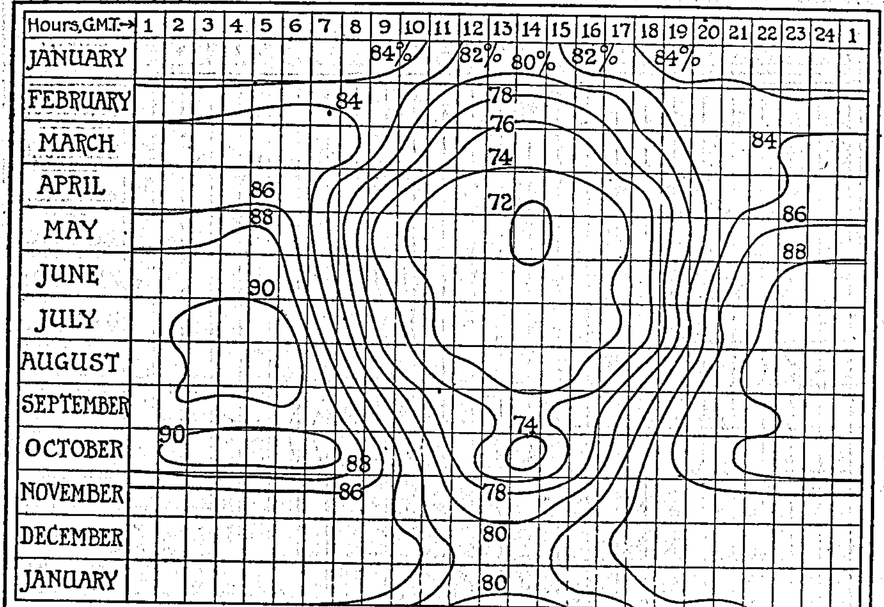
Mean Relative Humidity at ABERDEEN for 25 Years 1886-1910.
Isopleths Showing Seasonal and Diurnal Variation.

CLIMATIC DIAGRAM NO. 13.



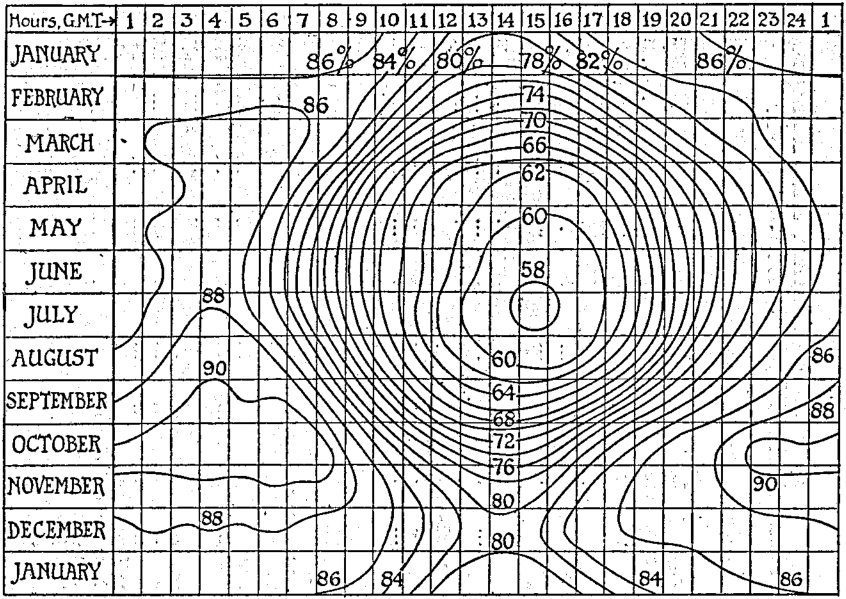
Mean Relative Humidity at VALENCIA for 25 Years 1886-1910.
Isopleths showing Seasonal and Diurnal Variation.

CLIMATIC DIAGRAM No. 14.



Mean Relative Humidity at FALMOUTH for 25 Years 1886–1910
Isopleths showing Seasonal and Diurnal Variation.

CLIMATIC DIAGRAM No. 15.



Mean Relative Humidity at KEW for 25 Years 1886~1910.
Isopleths showing Seasonal and Diurnal Variation.

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By DARLING AND SON, LIMITED, BACON STREET, E. 2

15600

E

CHARTS

SHOWING THE

Normal Distribution over the British Isles

IN

JANUARY AND JULY

OF

DAY AND NIGHT TEMPERATURE
(Reduced to Sea-Level),
DAILY DURATION OF BRIGHT SUNSHINE

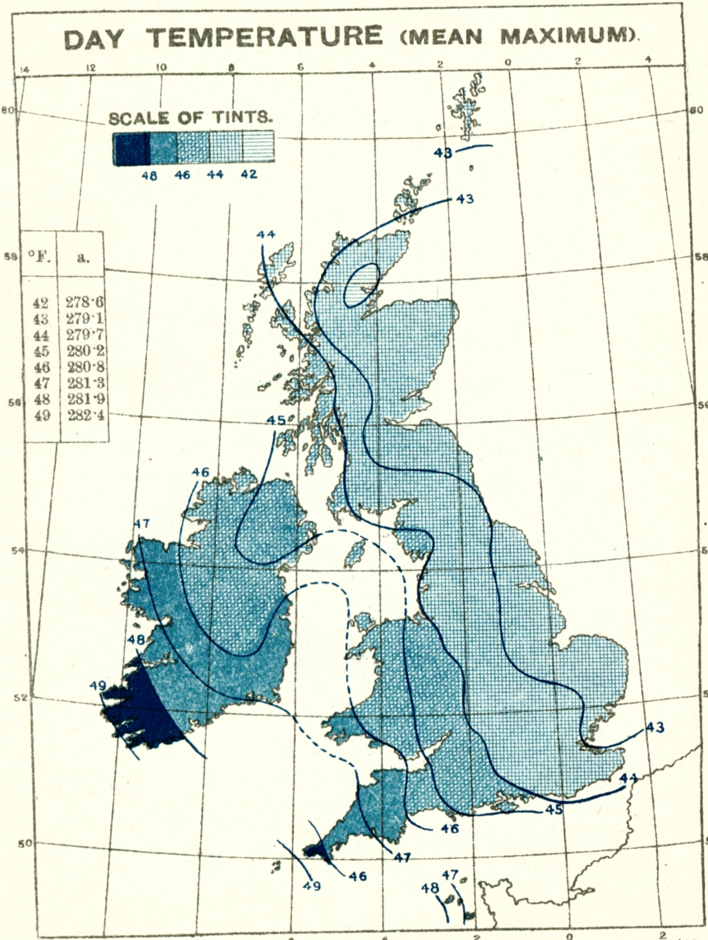
AND

AMOUNT OF RAINFALL.

The data upon which the Charts are based are published in M.O. Publication 214a, App. IV. For final maps of the normal distribution of rainfall and sunshine, records from a much larger number of stations are desirable.

Normal Distribution for JANUARY of Air

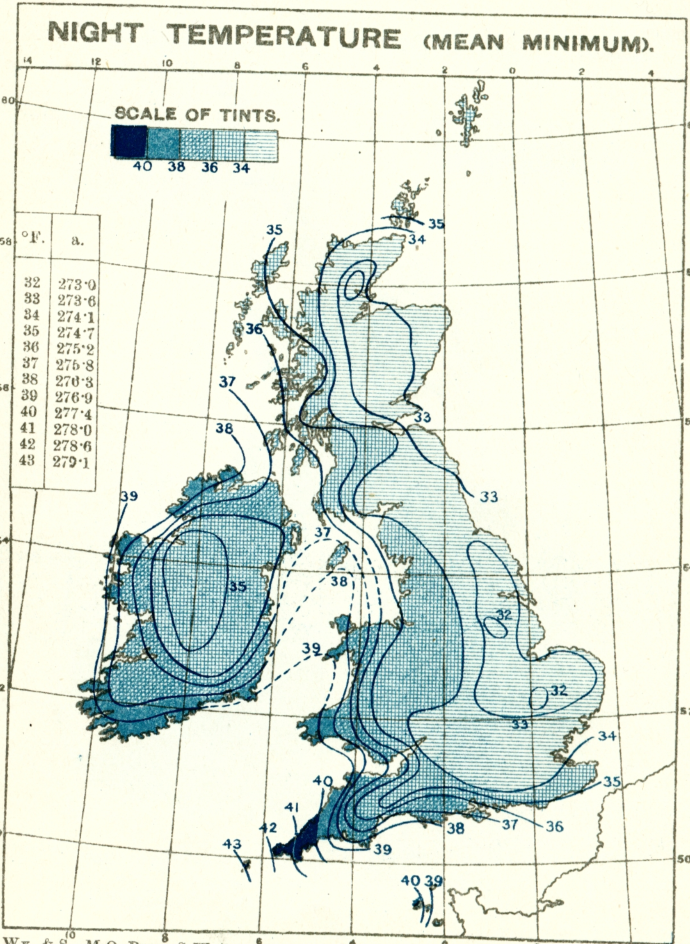
The isotherms are shown for intervals of 1°F. The corresponding



Wy. & S., M.O. Press, S.W. 7. Ps. 1115. 15246. 483. 6000. 1/18.

Temperature, reduced to Sea Level.

values on the Absolute Scale are given in the inset tables.



°F.	a.
32	273·0
33	273·6
34	274·1
35	274·7
36	275·2
37	275·8
38	276·3
39	276·9
40	277·4
41	278·0
42	278·6
43	279·1

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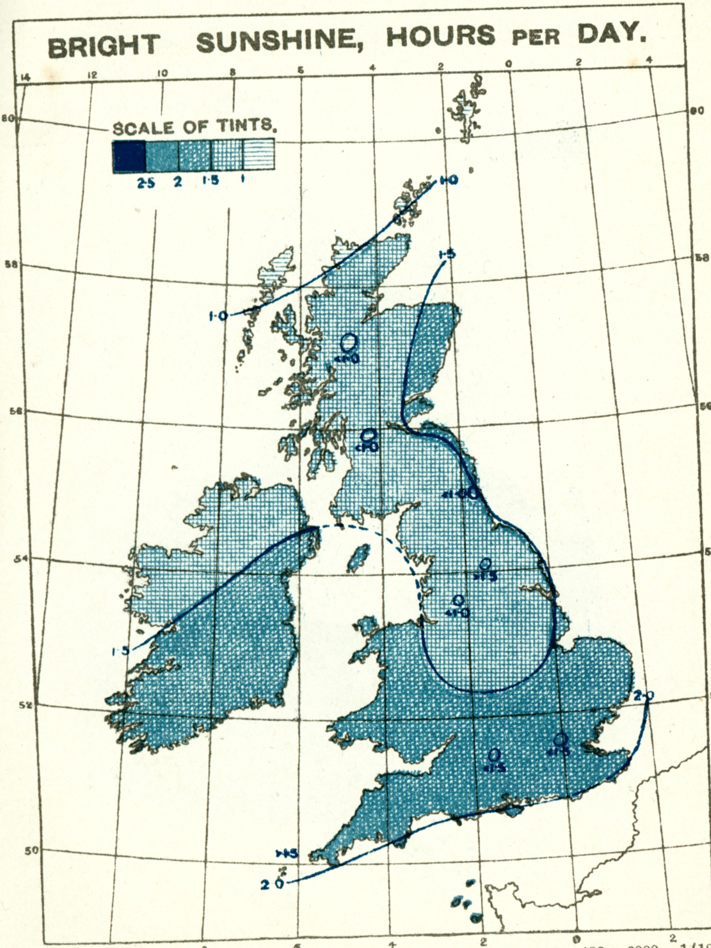

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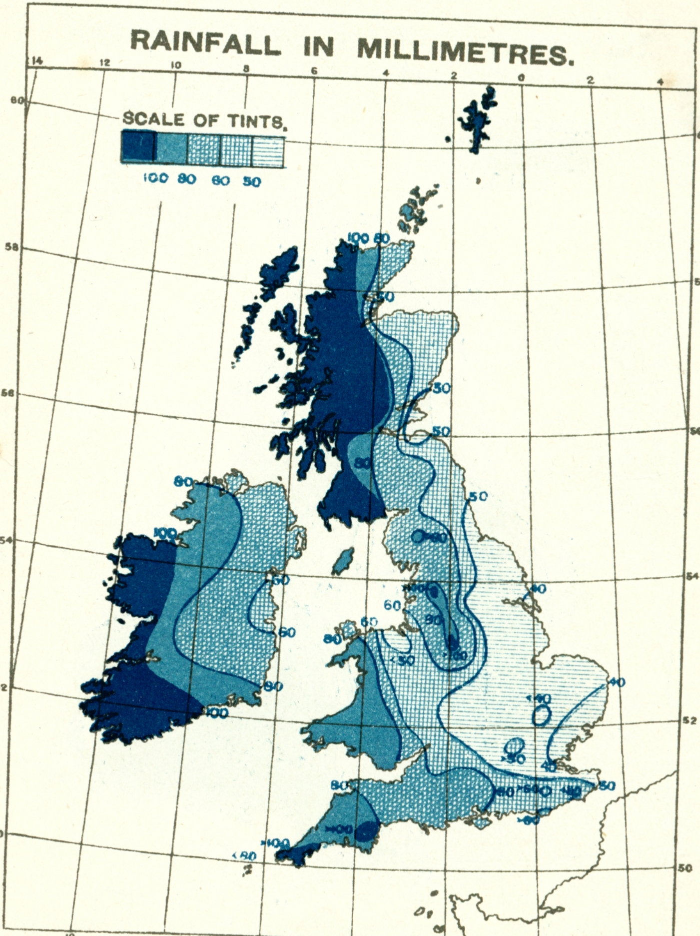
of Bright Sunshine and Rainfall.



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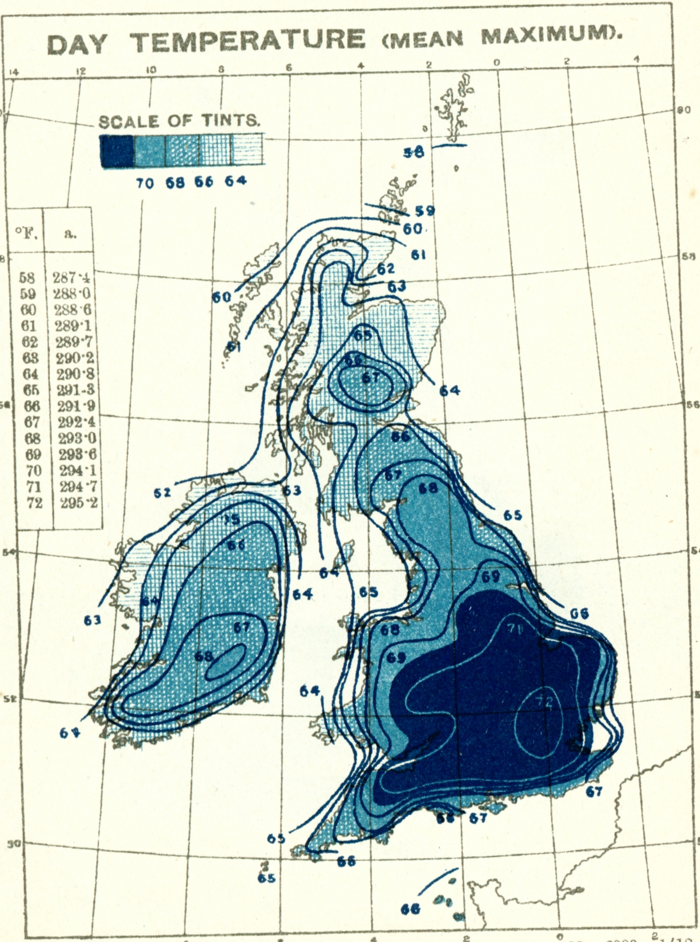
Normal Distribution for JULY of Air

The isotherms are shown for intervals of 1°F. The corresponding



°F.	a.
58	287·4
59	288·0
60	288·6
61	289·1
62	289·7
63	290·2
64	290·8
65	291·3
66	291·9
67	292·4
68	293·0
69	293·6
70	294·1
71	294·7
72	295·2

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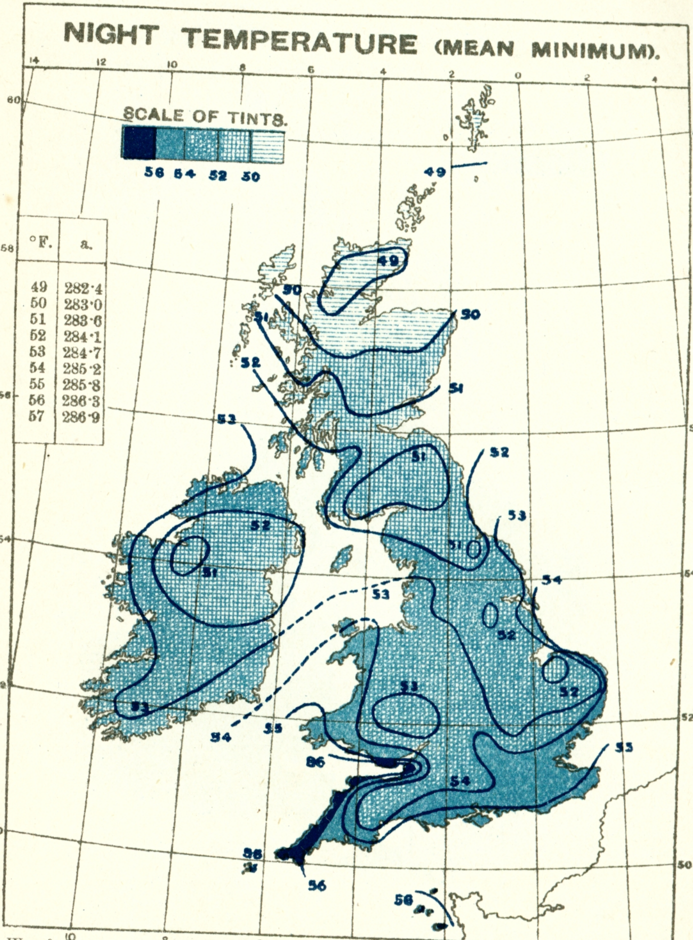
Temperature, reduced to Sea Level.

values on the Absolute Scale are given in the inset tables.



°F.	a.
49	282·4
50	283·0
51	283·6
52	284·1
53	284·7
54	285·2
55	285·8
56	286·3
57	286·9

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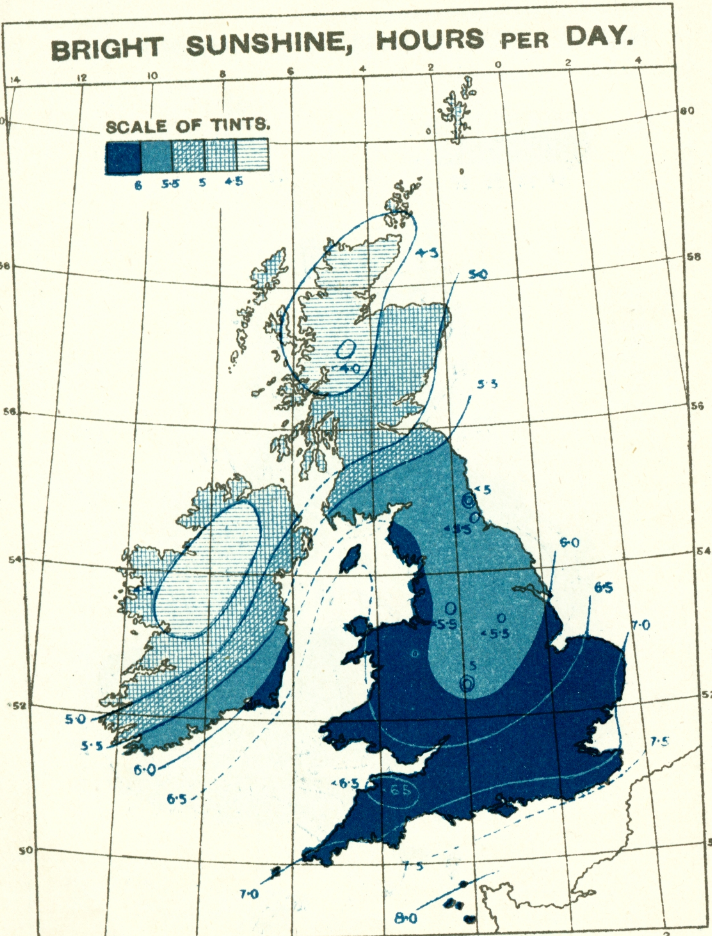
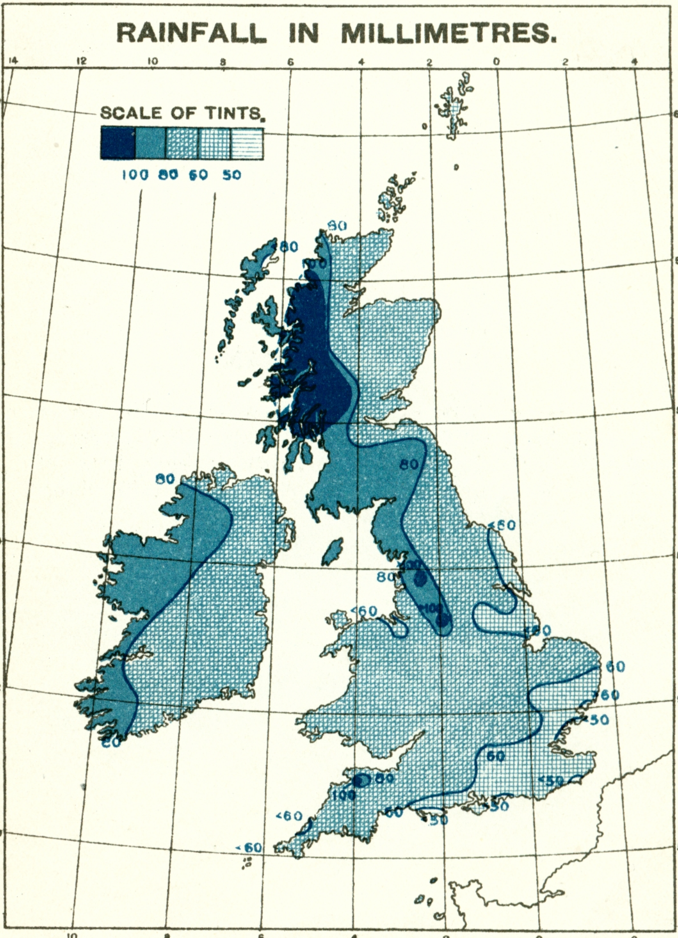


Wy. & S., M.O. Press, S.W. 7. Ps. 1115. 15246. 483. 6000. 1/18.

of Bright Sunshine and Rainfall.



Wy. & S., M.O. Press, S.W. 7. Ps. 1115. 15246. 483. 6000. 1/18.

CLIMATIC DIAGRAMS.

The fifteen diagrams which follow show, by means of isopleths, the normal values of temperature, pressure, wind, rainfall, and relative humidity at each hour of the day, in each month of the year, at certain observatories in the British Isles.