

# Symons's Meteorological Magazine.

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## ON WEATHER FORECASTS AND THE TEMPERATURE PREDICTIONS OF STRÖMBERG.

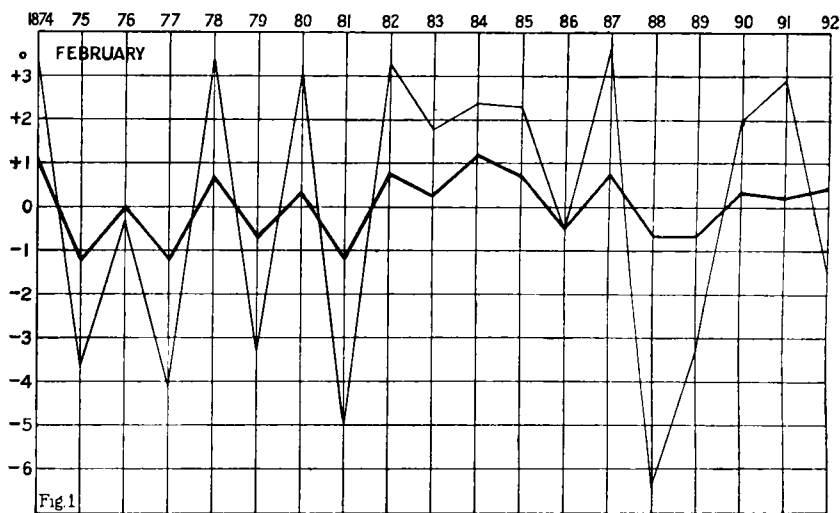
By DR. HANS PETTERSSON.

THERE are few if any scientific problems more fitted to attract general interest than those which have a bearing on weather predictions and climatic forecasts. Of the methods actually used for that purpose we may here pass over the most primitive, in which an important part is played by various physical ailments of the (generally aged) expert. Quite a different degree of confidence is naturally evoked by the simple rules and acute observations on which experienced farmers and weather-worn sailors base their forecasts of the local weather, very often with surprisingly correct results.

The official weather predictions issued by the meteorological offices of most civilized countries have, of course, a much more far-reaching importance. An intimate knowledge of the dynamical laws governing the lower strata of the atmosphere, combined with a vast system of organized international observation, enable meteorologists to foretell what state of weather is likely to prevail during the next 24 or 48 hours. A particularly useful kind of such short-range forecasts are the storm-signals, given for the benefit of the fishing and shipping industries, which have wrung a decided, although somewhat reluctantly granted, approval from the followers of these professions.

An altogether different kind of forecast is that which aims at predicting the average character of a coming season, months in advance. That such long-range forecasts are theoretically possible was first proved by Prof. Otto Pettersson. In a paper published in 1896 he draws attention to the intimate correlation which exists between the air temperature over Scandinavia in the winter and the surface temperature of the Norwegian Sea. Figure 1, which is taken from his paper, shows how the average air temperature (thin line) of February at Örebro (central Sweden), varies from year

to year, together with the simultaneous fluctuations in the temperature of the surface water off the west coast of Norway. The parallelism is certainly striking, and it is worthy of note how much larger are the temperature variations of the atmosphere than of the sea, obviously in consequence of the enormously higher heat-capacity of water than of air. Other curves no less convincing

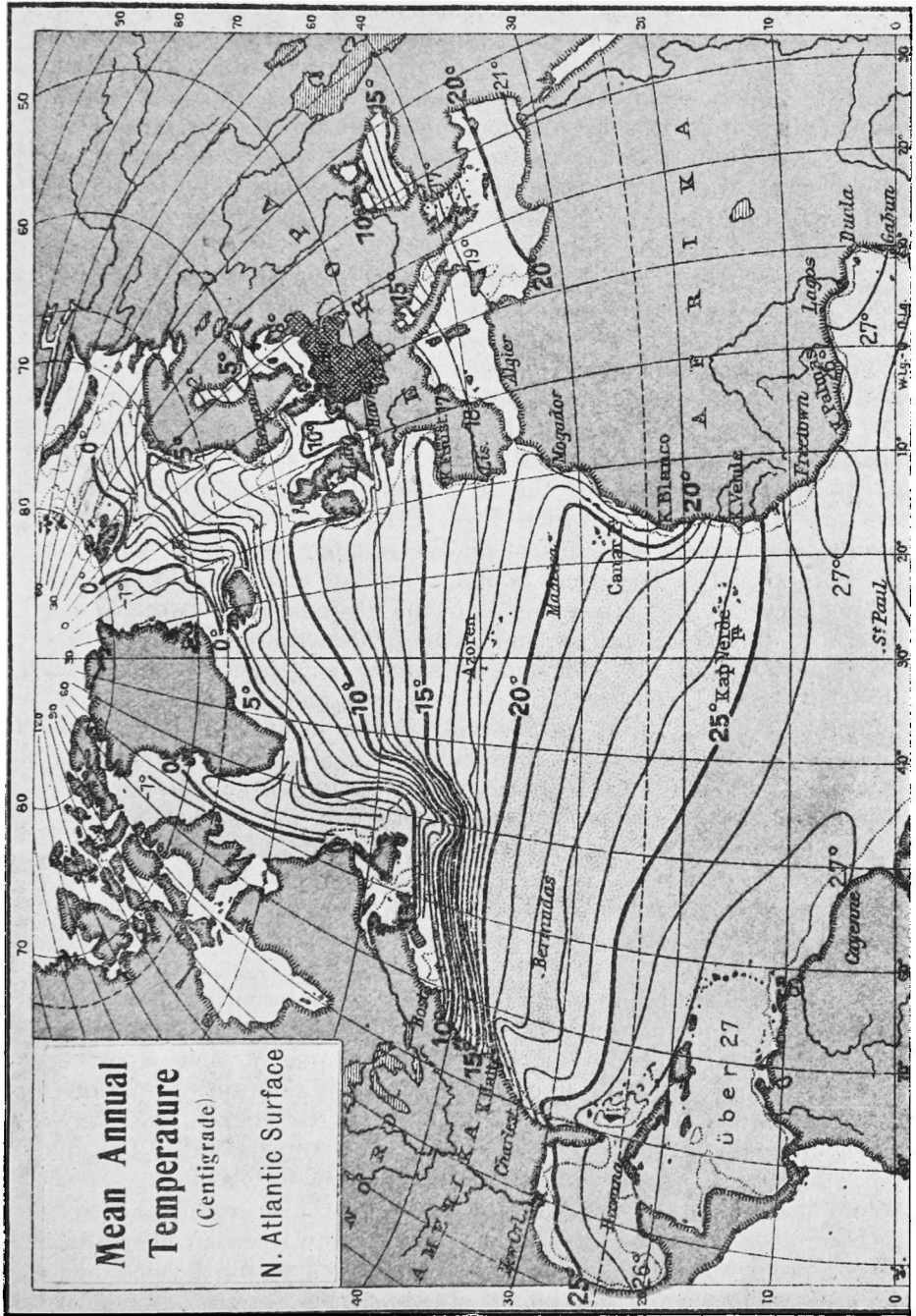


*Fig. 1.*—PARALLELISM BETWEEN AIR-TEMPERATURE AT ÖREBRO AND SURFACE TEMPERATURE OF NORWEGIAN SEA.

are also given in this paper, proving that similar correlations exist between the length of the Swedish winter (number of days with snow-covered ground), and the arrival of spring (commencement of ploughing), on one side, and the average surface temperature of February on the other.

Recent investigations by Prof. J. W. Sandström have revealed the vast system of atmospheric circulation, which is the immediate cause of this remarkable interdependence.

As a further proof of the large extent to which our climate is influenced by the ocean, especially in winter, I have reproduced in Figure 2 a map showing the annual isotherms of the N. Atlantic surface. Their conspicuous northward trend along the coasts of north-western Europe is the direct cause to which we owe our abnormally mild winter climate. If, now, large areas of this "hot-water pipe" of our part of the world undergo parallel variations in temperature from year to year (and such fluctuations have actually been proved to exist by the recent investigations of Prof. Fridtjof Nansen and Prof. Helland-Hansen), then these cannot fail to have a corresponding influence on the European climate, By systematic investigation of the heat-supply carried by the vast



warm currents along the coast of N. America, one should, therefore, be able to foretell an abnormally severe or mild European winter. One may hope to gain valuable clues in this way also for rainfall predictions, as the rate of evaporation from the ocean depends largely on its surface temperature. It is, therefore, most satisfactory that the International Council for the investigation of the sea is now about to extend its field of research to the larger expanse of the North Atlantic. The Meteorological Offices of Great Britain and of Holland are already publishing valuable material on the same subject.

Quite recently a young Swedish astronomer, Dr. Gustaf Strömberg, has made a most interesting attempt at a new kind of long distance forecasts of the weather or rather of the air-temperature. When the large submarine (boundary) waves, discovered by Prof. Otto Pettersson on the west coast of Sweden, were being studied, Dr. Strömberg had assisted by making a so-called "harmonic analysis" of the wave record. The object was to trace in the phenomenon the effect of the long-periodical tidal forces of the sun and the moon, to which Prof. Pettersson's climatic theories ascribe a far-reaching influence on the oceanic circulation and on the climate. The fact that boundary waves are also a frequent phenomenon in the atmosphere on the boundaries between air-layers of different densities, naturally suggested that atmospheric phenomena might also respond to similar long-period influences. It occurred to Strömberg that a harmonic analysis of the same kind might be made on the air-temperature records of Stockholm and Upsala. The results of a preliminary analysis were promising, and Dr. Strömberg was encouraged by several Swedish men of science to pursue his investigations, the not inconsiderable cost being defrayed by liberal grants from private donors.

It may be of interest to give here a brief sketch of the method employed, the harmonic analysis, which, thanks to the work of Lord Kelvin and others, has given such brilliant results at tidal predictions.

Suppose that we have plotted a curve representing how the average daily temperature of a certain locality varies during a number of years. To predict the future course of such a curve from its past is obviously impossible if there is no kind of relationship between different parts of that curve, if its course, from any given day and onwards, is merely a matter of chance. But, on the other hand, *if there are persistent elements of regularity*, law-bound fluctuations, present in the curve, but obscured, either by their number or by the interference of other and irregular elements, then a prediction of at least partial correctness should be possible.

From a mathematical point of view the simplest kind of "regular," *i.e.*, periodically fluctuating curves, is the so-called sine-curves ( $y = A \sin x$ , where  $A$  is a constant), a kind of wave-

line with constant amplitude or "height of the waves," and constant period or "wave-length." Two different sine-curves are given in Figure 3, I. and II. ( $AB = CD = EF$ ;  $AC = CE$  and  $ab = cd = ef$ ;  $ac = ce$ ). Curve III. is the graphical sum of I. and II., its ordinates (vertical distance of the curve from its axis,  $a\Delta$ ), being everywhere equal to the sum of the homologous ordinates in the two simple curves ( $a\beta = AB + a_1b_1$  and  $\Delta\gamma = CD - c_1d_1$ ). The shape of Curve III. is evidently of a much more complex regularity than that of its components. If now, instead of only two sine-curves, twenty or thirty had been added together, the resultant curve would obviously have become so complex that a

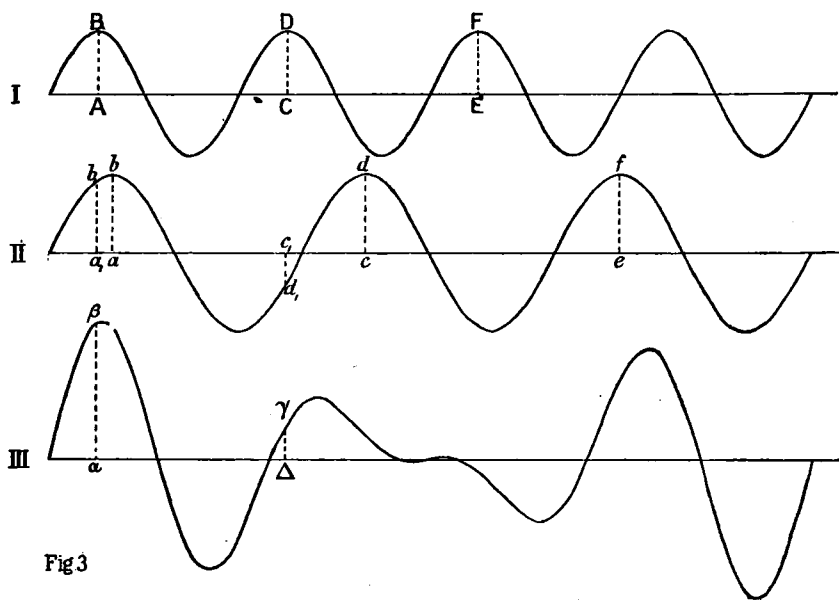


Fig. 3.—A COMPLETE CURVE (III.) AND ITS SIMPLE COMPONENTS, SINE-CURVES (I. AND II.).

prediction of its future course from a certain point would be practically impossible. But if one could only resolve such a complex curve into its simple components, then from the future courses of all these (which are self-evident), the future course of their sum could be synthetized. By means of a harmonic analysis such a resolution of a complex curve into elementary waves (or rather their *extrication* from the mother-curve), can be realized. \*

Suppose that we want to find out whether there is a periodicity of, say, 20 days' length present in the record mentioned above. For that purpose we must first divide the whole length of the

\*A similar analysis is achieved by any musical person when he distinguishes by the ear the different simple musical tones from which an intricate struck on the piano is built up.

curve into equal fractions, each 20 days long. Then through a simple but laborious arithmetical operation (taking mean values from homologous ordinates), we construct the *average shape* of all the fractions. In a similar way one may find the characteristic features of a family by photographing its different members on the same negative. Now if there is no persistent periodicity of the given length present in the curve, there will be no "family likeness" between its different fractions; and their average shape will be an irregular line which deviates from the straight axis only by small amounts according to the law of errors. But if there is really such a periodicity hidden in the curve, then the "family likeness" will come out in the result, the average shape being in the simplest case, one complete wave of a sine-curve twenty days long. The amplitude of that elementary temperature wave evidently denotes to what extent the temperature curve is influenced by a periodicity of 20 days. And all along the length of the record investigated an uninterrupted train of such sine-waves must be considered to run, although they may be completely obscured by other superposed variations, periodical or unperiodical.

Being under the influence of Prof. Pettersson's climatic theories, Dr. Strömberg at first only tried to find temperature-waves of the same length as the lunar periods or derivable from these in conjunction with solar periods. He afterwards made an unprejudiced analysis testing the record for all periodicities between 20 and 40 days long, and varying the length of the investigated period by only .02 of a day at each new attempt. No less than between 30 and 40 different elementary temperature waves have thus been extricated from the last thirty years' record of Stockholm, their amplitudes varying between  $\pm 0^{\circ}17$  C and  $\pm 0^{\circ}30$  C, i.e., a total fluctuation due to each of from  $0^{\circ}35$  C to  $0^{\circ}60$  C. On the other hand it can be proved that any fictitious periodicity, which might be artificially produced by testing sharpness of the analysis, would, according to the law of errors, have an average amplitude of only  $\pm 0^{\circ}05$  C. There is, consequently, a wide margin between that value and the amplitude of the smallest waves accepted by Dr. Strömberg as actually present in the record.

However, as a further proof of the real existence of these temperature waves, Strömberg has checked his calculations by dividing the investigated record into two equal parts and analysing each part separately. Not only do the same waves then come out in both parts, but even their amplitudes are approximately the same, and also their "angles of phase" are practically identical, so that the train of each wave running through the first part of the record is smoothly linked up with its partner in the second half without any discontinuity, i.e., without any sudden change of phase at the point of division.

(To be continued).

## Correspondence.

To the Editor of Symons's Meteorological Magazine.

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## THE SEASONS: THE FINAL REPLY.

IN his letter last month Mr. Ellis touches points concerned with two principles which I have for a long time past been labouring to get more thoroughly understood. Firstly, it is not the air temperature alone considered that is held in primary regard by living creatures, but it is the air temperature taken in conjunction with the effects of direct radiation of heat and light which transcends any other meteorological element. If, for example, we compare a rather cool bright day with a shade temperature say between  $65^{\circ}$  and  $70^{\circ}$  in the high solstitial month of June with a similar day of the same temperature in the transitional equinoctial month of September.\* We are forced to admit that the June day is, in a more complete sense, the hotter, because in that month the sun's rays smite the ground like a shaft, whereas in September they are much milder, and not generally felt to be oppressive unless associated with a high air temperature like  $80^{\circ}$ . Indeed, I fail to see how some of the seasonal habits of animal life can be interpreted except on the supposition that they are even more closely related to radiation than to air temperature.

The second principle brought out by the examination of Mr. Ellis's letter is one which strikes me with overwhelming force every May and November—solstitial months not included in the conventional summer and winter. Mr. Ellis apparently regards the incidence of the thunderstorm season around the summer solstice and of the cyclonic gale and the fog season around the winter solstice as an "accidental" relationship, in so far, that is to say, as the arrangement of the seasons should be concerned. The relationship, however, is of fundamental importance, not indeed so much because of the phenomena of gales and thunderstorms themselves, which only occur from time to time, as because their frequency and intensity is an index that the general body of the atmosphere is under *solstitial control*—by a direct physical process in the case of thunderstorms at the high solstice, and by an indirect process in the case of cyclonic gales and of fogs at the low solstice.† Everyone will of necessity admit this; yet they cannot follow my constant assertion variously expressed that solstitial control over pressure distribution and weather types is the first and foremost

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\* It is obvious that for such equality of temperature to occur, the air on the June day must be of cooler *origin*.

† The energy, concentrated in local patches, of our summer thunderstorms proceeds from solar action; the more uniform energy of our winter gales is an indirect result of the absence of powerful insolation.

meaning of summer and winter, even though the general level of air temperature is higher and lower respectively in the first equinoctial than in the first solstitial months. In all the diverse characterisation of sky and weather which mark the effects of intense insolation, the month of May is kith and kin with June and July, a fact splendidly illustrated by the similar thunder-storm energy of May in spite of the lower temperature. Therefore, I say it is monstrously incorrect to exclude May from an arrangement which includes either three or four months of summer.

To turn now to Mr. Luttrell's letter, I hardly think he has a clear idea of the question at issue, for there is nothing in my four previous contributions to this subject that can possibly justify his charge of my disregarding the Atlantic influence on the climate of the British Isles; moreover, the matter is rather beside the mark; but I will take Mr. Luttrell a step farther in his own direction than he thought, perhaps, of going. I am aware that in extremely oceanic regions like Valentia and our western sea-board generally, where the change of temperature from month to month is very small, September and March are warmer and colder respectively not only than May and November, but slightly so even than June and December. Does Mr. Luttrell then, as logically he ought, put forth this small excess of air warmth in September as an argument for replacing June by September among the three months of the oceanic summer? or does he more wisely perceive that such a trifling temperature concern is completely drowned by the equinoctial conditions of September with the on-coming winter storms?

As regards the question of snowfall, broached by Mr. Luttrell, I believe I am right in saying that no month of the year in England can be pronounced absolutely immune from frost and snow. In the warmer southern localities, however, like London, away from the chilling influence of mountains, the chances of anything that could fairly be called a snowstorm, are almost nil in each of the six months May to October. Now April is far more prone to snow than October, yet no meteorologist on that account denies to the former its legitimate place in the summer half year, and we have a whole host of summer migrant birds willing to brave a little touch of ice and snow in sunny April that would be frightened out of their wits, if forced to stay here during the chill, darkening days of October. If meteorologists, in short, arrange the *six* months of summer by the sun, why will they not be consistent and judge the *three* months of summer by the same standard?

It is to be noted by the way that Mr. Luttrell's letter contains a curious little clause to the effect that in the west country "summer seldom asserts itself before *mid-summer*" (*italics mine*). By "midsummer," I take it that he is here thinking of the June solstice, and if so he is conceding the very point at issue, and we may part company with a cordial handshake. His remarks about



the seasonal peculiarities of the west of England, are, of course, just another way of saying that the mean temperatures lag behind the solstices, is even more marked in the sea-ward projecting western counties than it is "up-country." It may be noted, however, in passing, that in some years even in England the only severe cold spell of a winter occurs in November, *e.g.*, winter of 1904-5, and the only severe heat of a summer in May, *e.g.*, 1913, when for six consecutive days the temperature rose above 80° in the shade, with sultry nights.

From his letter in the July number the Rev. G. Weston seems aware of the hard contest between May and August that will always be fought if we try and limit the summer to three months. But inasmuch as the solstitial periods are longer than the equinoctial, roughly embracing four months each against only two each for the latter, a scientific escape from the difficulty is afforded in making the summer consist of the four months May to August, and the winter of the four months November to February. It will be found on studying the almanac that as early as April 22nd, and as late as August 22nd, the sun's declination is nearer that of the summer solstice than that of the equinoxes; and a similar relationship exists in the winter, except that the winter solstitial period is somewhat shorter than the summer. I am arguing not so much for the exclusion of August and February from the summer and winter respectively as for the necessary inclusion of May and November.

Finally, in taking leave of my critics, I would ask them in further reflection to reduce the matter to its elements by casting the names "spring," "summer," "autumn," and "winter," into the melting pot, and fixing their attention on the idea of *family* relationship between the months. Then let them answer the following question:—Is the seasonal lag in the air-temperature viewed in the light of the full climatic picture of sufficient magnitude *really* to justify the division of such clearly marked natural groups of three months as are indicated, on the one hand, by the 4 p.m. night-fall, and, on the other hand, by the 9 p.m. day-light? This is a searching inquisition, but every individual answer, whensoever it is made, will be the more valuable on that account.

L. C. W. BONACINA.

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### LIGHTNING HOLES.

WITH reference to Mr. Dines' letter *re* holes caused by lightning, on page 97 of July, 1915, *Meteorological Magazine*, I think the holes may have been caused by an *upward* stroke of lightning from the ground; as I remember seeing a flag pole on a Torquay house and a telegraph post on a Cornish moor, that had been struck by

lightning, showed wood strips apparently chiselled out from *below* towards the middle of the post, and above the middle had been chiselled from above; I fancy lightning sometimes strikes in both directions (from above and below), but is only *visible* in one direction.

E. E. GLYDE.

323, Ross Street, Edmonton, Alberta, Canada.

YET more conclusive instances of "lightning holes" are on record than is mentioned on page 108 of your last number. At page 60, Vol. 45 (1889), of the Geological Society's *Quarterly Journal*, the late Mr. F. Rutley describes fulgurites from Monte Viso, obtained by the late Mr. James Eccles, from close to the summit of that peak (12,609 feet). The rock was one of the *Grünen-schiefer* group (with some glaucophane), and in it channels had been ploughed which were lined with a glass. In the same journal, Vol. 52 (1896), page 452, I described (in a joint paper with Miss Aston), specimens, brought by the same geologist and Alpine climber, from the summit of the Riffelhorn (9,617 feet), which he presented to the Geological collection at University College. Some of these fulgurites are actual tubes, which might be compared to small worm-burrows, coated with a film of very dark glass, the rock being an antigorite-serpentine. In F. A. Fitzgerald's "Highest Andes," (1899), I describe at page 325, fulgurites in blocks of hornblende-andesite, from the summit of Tupungato (20,260 feet). These also are channels and tubes, sometimes branching, as in the other instances, fairly circular in section, often from one-fifth to one-third of an inch in diameter, and with a rather thin coating of bottle-green glass. The description is reprinted in the *Geological Magazine* (1899, page 1).

T. G. BONNEY.

### DEFINITION OF A "PARTIAL RAIN SPELL."

FROM the 28th of June to the 17th of August we never had two consecutive days without rain, but as there were some rainless days interspersed among the 37 rain days during that period, it cannot be spoken of as a "rain spell."

It seems a pity that no definition has been agreed upon for a *partial* rain spell, similar to that for a partial drought, to designate a period in which there has been a long succession of wet days, although a few rainless days have precluded it from being called an absolute rain spell. It would be interesting if any suggestions as to the actual form of the definition were made in this magazine. My own opinion is that the definition might run: "*A Partial Rain Spell* is a period of more than 28 consecutive days in which there were never more than two consecutive days without rain."

A. E. SWINTON.

Swinton House, Duns, 1st September, 1915.

## REVIEW.

*Republica de Chile. Anuario del Servicio Meteorológico de la Direccion del Territorio Maritimo, 1910.*; (Annual of the Maritime Meteorological Service of Chile, 1910). Valparaiso, 1912. Size  $10\frac{1}{4}+7\frac{1}{4}$ . Pp. 7 + 464, and plates.

THIS work gives *in extenso* the tri-daily observations carried on at 18 stations on the Chilian littoral during the year 1910, and concludes the 12 years' work of the Maritime Weather Service, which was amalgamated in 1911 with the newly constituted Meteorological and Geo-Physical Institute. The stations cover nearly  $35^{\circ}$  of latitude, and thus the records embrace all varieties of climate. At the two northern stations of Arica and Iquique no rain fell in 1910, while at Evangelists Island near the Pacific entrance to Magellan Straits 124.20 in. fell on 314 days, with a maximum daily fall, however, of only 2.44 in. The month of December was rainless at some wet stations situated in lat.  $40^{\circ}\text{S}$ , this being the first instance of a month without rain in this region. Although some of the material requires to be subjected to a critical examination or analysis before being utilised for scientific purposes, the *Territorio Maritimo* deserve every credit for having prepared and published annually since 1899 the reports of which the one under notice is the final issue. In spite of the great strides made in other directions since the beginning of the century by several Weather Services in the Southern Continents, none has given their annual reports in such a complete form as Chile. In connection with the new and wider outlook into meteorological problems, more particularly those relating to long range forecasting, it is absolutely necessary that the Southern Weather Services should each publish promptly a monthly bulletin of the more essential data. This is already done by Australia and New Zealand, and until recently by Argentina, which gave monthly maps without the numerical data. Other services will, however, have to fall into line in this direction if the sum and substance of Southern Hemisphere meteorology is to be promptly utilised for practical purposes, more particularly in connection with agriculture.

R.C.M.

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 METEOROLOGICAL NEWS.

SNOW FELL IN KIMBERLEY, SOUTH AFRICA this winter, an event of the utmost rarity, in commenting upon which Mrs. Sutton says in a letter dated July 29th, "people all turned out to snowball, and the natives, many of whom had never seen such a sight before, were most excited. My native charwoman told me when she woke in the morning, that she thought some one had been breaking into the shops, and had scattered flour all over the place!"

## RAINFALL TABLE FOR AUGUST, 1915.

STATION.	COUNTY.	Lat. N.	Long. W. [*E.]	Height above Sea. ft.	RAINFALL OF MONTH.	
					Aver. 1875— 1909. in.	1915. in.
Camden Square.....	London .....	51 32	0 8	111	2'39	2'27
Tenterden .....	Kent .....	51 4	*0 41	190	2'42	1'56
Arundel (Patching).....	Sussex .....	50 51	0 27	130	2'52	2'35
Fawley (Cadland) .....	Hampshire .....	50 50	1 22	52	2'85	1'83
Oxford (Magdalen College).....	Oxfordshire ...	51 45	1 15	186	2'44	1'31
Wellingborough(Swanspool).....	Northampton....	52 18	0 41	155	2'36	2'03
Shoeburyness.....	Essex .....	51 31	*0 48	13	1'74	2'88
Bury St. Edmunds(Westley).....	Suffolk .....	52 15	*0 40	226	2'52	2'13
Geldeston [Beccles].....	Norfolk .....	52 27	*1 31	38	2'22	1'65
Polapit Tamar [Launceston].....	Devon .....	50 40	4 22	315	3'17	2'21
Rousdon [Lyme Regis] .....	" .....	50 41	3 0	516	2'84	1'91
Stroud (Upheld) .....	Gloucestershire..	51 44	2 13	226	2'90	3'53
Church Stretton (Wolstaston).....	Shropshire .....	52 35	2 48	800	3'43	3'45
Boston .....	Lincolnshire.....	52 58	0 1	11	2'39	2'56
Workshop (Hodsock Priory).....	Nottinghamshire	53 22	1 5	56	2'55	3'18
Mickleover Manor .....	Derbyshire .....	52 54	1 32	280	2'80	2'69
Macclesfield .....	Cheshire .....	53 15	2 7	501	3'76	3'52
Southport (Hesketh Park).....	Lancashire .....	53 39	2 59	38	3'73	3'57
Arncliffe Vicarage .....	Yorkshire, W.R.	54 8	2 6	732	5'62	4'02
Wetherby (Ribston Hall) ...	" .....	53 59	1 24	130	2'78	1'93
Hull (Pearson Park) .....	" E.R. ....	53 45	0 20	6	3'05	2'29
Newcastle (Town Moor) ...	Northumberland	54 59	1 38	201	3'20	2'25
Borrowdale (Seathwaite) ...	Cumberland.....	54 30	3 10	423	11'47	4'25
Cardiff (Ely).....	Glamorgan .....	51 29	3 13	53	4'54	1'66
Haverfordwest.....	Pembroke .....	51 48	4 58	90	4'21	1'76
Aberystwyth (Gogerddan).....	Cardigan .....	52 26	4 1	83	4'88	2'56
Llandudno .....	Carnarvon .....	53 20	3 50	72	3'16	3'26
Cargen [Dumtries] .....	Kirkcudbright...	55 2	3 37	80	4'23	2'70
Marchmont House .....	Berwick.....	55 44	2 24	498	3'54	3'35
Girvan (Pinnmore).....	Ayr .....	55 10	4 49	207	4'54	1'66
Glasgow (Queen's Park) .....	Renfrew .....	55 53	4 18	144	3'62	...
Inveraray (Newtown) .....	Argyll .....	56 14	5 4	17	6'02	3'05
Mull (Quinish).....	" .....	56 34	6 13	35	5'00	1'95
Dundee (Eastern Necropolis).....	Forfar .....	56 28	2 57	199	3'34	3'67
Braemar .....	Aberdeen .....	57 0	3 24	1114	3'63	3'04
Aberdeen (Cranford) .....	" .....	57 8	2 7	120	3'07	1'46
Gordon Castle .....	Moray .....	57 37	3 5	107	3'29	3'16
Fort Augustus(S. Benedict's).....	E. Inverness ...	57 9	4 41	68	3'52	3'00
Loch Torridon (Bendamph).....	W. Ross .....	57 32	5 32	20	6'61	6'90
Dunrobin Castle .....	Sutherland .....	57 59	3 56	14	2'71	1'02
Wick .....	Caitness .....	58 26	3 6	77	2'73	'90
Killarney (District Asylum).....	Kerry .....	52 4	9 31	178	4'57	3'29
Waterford (Brook Lodge).....	Waterford .....	52 15	7 7	104	3'73	2'36
Nenagh (Castle Lough).....	Tipperary.....	52 54	8 24	120	4'04	3'43
Ennistymon House.....	Clare .....	52 57	9 18	37	5'01	3'79
Gorey (Courtown House) ..	Wexford .....	52 40	6 13	80	3'31	2'69
Abbey Leix (Blandsfort).....	Queen's County..	52 56	7 17	532	3'94	2'93
Dublin(Fitz William Square).....	Dublin .....	53 21	6 14	54	3'08	2'38
Mullingar (Belvedere).....	Westmeath .....	53 29	7 22	367	4'00	5'37
Crossmolina (Enniscoe).....	Mayo.....	54 4	9 16	74	4'68	3'01
Cong (The Glebe).....	" .....	53 33	9 16	112	4'70	4'66
Collooney (Markree Obsy.).....	Sligo .....	54 11	8 27	127	4'30	3'21
Seaforde .....	Down.....	54 19	5 50	180	3'64	3'56
Bushmills (Dundarave).....	Antrim .....	55 12	6 30	162	4'06	...
Omagh (Edenfel).....	Tyrone .....	54 36	7 18	280	4'22	3'24

Errata—Inveraray, June, Diff. from Av. +2.42  
 " " July, " " +1.55

## SUPPLEMENTARY RAINFALL, AUGUST, 1915.

Div.	STATION.	Rain inches	Div.	STATION.	Rain inches
II.	Warlingham, Redvers Road .	2·75	XI.	Lligwy .....	2·56
„	Ramsgate .....	2·00	„	Douglas .....	2·01
„	Hailsham .....	1·39	XII.	Stoneykirk, Ardwell House...	1·45
„	Totland Bay, Aston House...	·89	„	Carsphairn Shiel .....	3·50
„	Stockbridge, Ashley .....	1·45	„	Beattock, Kinnelhead .....	2·76
„	Grayshott .....	3·13	„	Langholm, Drove Road .....	2·37
III.	Harrow Weald, Hill House...	2·59	XIII.	Meggat Water, Cramilt Lodge	3·62
„	Caversham, Rectory Road ...	2·67	„	North Berwick Reservoir...	4·64
„	Pitsford, Sedgebrook.....	1·72	„	Edinburgh, Royal Observaty.	5·67
„	Woburn, Milton Bryant.....	2·01	XIV.	Maybole, Knockdon Farm ...	2·00
„	Chatteris, The Priory.....	2·33	XV.	Ballachulish House .....	3·18
IV.	Elsenham, Gaunts End .....	3·26	„	Campbeltown, Witchburn ..	2·69
„	Colchester, Hill Ho., Lexden	2·11	„	Holy Loch, Ardnadam .....	4·65
„	Ipswich, Rookwood, Copdock	2·78	„	Islay, Eallabus .....	1·32
„	Blakeney .....	1·35	„	Tiree, Cornaigmore .....	1·18
„	Swaffham .....	2·02	XVI.	Dollar Academy .....	4·20
V.	Bishops Cannings .....	2·51	„	Balquhider, Stronvar .....	4·13
„	Wimborne, St. John's Hill ...	1·37	„	Glenlyon, Meggernie Castle..	3·21
„	Ashburton, Druid House .....	2·46	„	Blair Atholl .....	3·76
„	Cullompton .....	2·53	„	Coupar Angus .....	3·89
„	Lynnmouth, Rock House .....	1·99	„	Montrose, Sunnyside Asylum.	2·44
„	Okehampton, Oaklands .....	3·22	XVII.	Alford, Lynturk Manse .....	2·18
„	Hartland Abbey .....	1·80	„	Fyvie Castle .....	1·86
„	Probus, Lamellyn.....	1·36	„	Keith Station .....	3·10
„	North Cadbury Rectory.....	3·48	XVIII.	Rothiemurchus .....	3·65
VI.	Clifton, Pembroke Road.....	2·31	„	Loch Quoich, Loan .....	9·40
„	Ross, The Graig .....	2·45	„	Drumadrochit .....	2·16
„	Shifnal, Hatton Grange.....	2·71	„	Skye, Dunvegan .....	2·37
„	Droitwich .....	1·68	„	Lochmaddy, Bayhead .....	3·60
„	Blockley, Upton Wold.....	2·17	„	Glencarron Lodge .....	6·47
VII.	Market Overton .....	2·30	XIX.	Invershin .....	1·25
„	Market Rasen .....	2·68	„	Melvich .....	2·23
„	Bawtry, Hesley Hall .....	2·17	„	Loch Stack, Achfary .....	7·91
„	Derby, Midland Railway.....	2·12	XX.	Dunmanway, The Rectory ..	2·71
„	Buxton .....	4·14	„	Glanmire, Lota Lodge.....	2·37
VIII.	Nantwich, Dorfold Hall .....	2·48	„	Mitchelstown Castle .....	2·45
„	Chatburn, Middlewood .....	5·72	„	Darrynane Abbey.....	3·57
„	Lancaster, Strathspey .....	4·06	„	Clonmel, Bruce Villa .....	2·36
IX.	Langsett Moor, Up. Midhope	3·81	„	Newmarket-on-Fergus.Fenloe	4·30
„	Scarborough, Scalby .....	3·00	XXI.	Laragh, Glendalough .....	...
„	Ingleby Greenhow .....	2·55	„	Ballycumber, Moorock Lodge	2·76
„	Mickleton .....	2·10	„	Balbriggan, Ardgillan .....	3·26
X.	Bellingham, High Green Manor	3·17	XXII.	Ballynahinch Castle.....	4·45
„	Ilderton, Lilburn Cottage ...	2·77	„	Woodlawn .....	5·38
„	Keswick, The Bank.....	2·67	„	Westport, St. Helens .....	3·46
„	Llanfrechfa Grange .....	2·30	„	Dugort, Slievemore Hotel ..	2·27
XI.	Treherbert, Tyn-y-waun .....	5·92	„	Mohill Rectory .....	4·86
„	Carmarthen, The Friary .....	2·52	XXIII.	Enniskillen, Portora .....	...
„	Fishguard Goodwick Station.	1·22	„	Dartrey [Cootehill] .....	4·05
„	Crickhowell, Tal-y-maes .....	4·00	„	Warrenpoint, Manor House ..	3·17
„	New Radnor, Ednol .....	2·60	„	Banbridge, Milltown .....	3·51
„	Birmingham WW., Tyrmynydd	4·79	„	Belfast, Cave Hill Road .....	4·34
„	Lake Vyrnwy .....	3·56	„	Ballymena Harryville .....	2·61
„	Llangynhafal, Plâs Draw.....	5·36	„	Londonderry, Creggan Res...	4·02
„	Dolgelly, Bryntirion.....	3·30	„	Dunfanaghy, Horn Head ...	3·15
„	Bettws-y-Coed, Tyn-y-bryn...	...	„	Killybegs .....	2·69





# THAMES VALLEY RAINFALL — AUGUST, 1915.



ALTITUDE  
SCALE

Below 250 feet    250 to 500 feet    500 to 1000 feet    Above 1000 feet

SCALE OF MILES

0 5 10 15 20



## THE WEATHER OF AUGUST.

THE characteristic features of the weather of August were a mean temperature in excess of the normal, a marked deficiency of sunshine, and a large number of thunderstorms. The warmth and cloudiness were most pronounced in Scotland, where the mean temperature was  $1^{\circ}5$  above the normal and where the average deficiency of sunshine amounted to slightly over one hour a day. In the south and south-west of England, including the Channel Islands, conditions did not depart much from the average.

The month opened with a low pressure area off the west of Ireland and high pressure systems to the south-west and north-east, and this type of pressure distribution with some slight modifications prevailed during the first half of the month. On the 2nd, when the low pressure system had moved south-eastward to the Cornish coast, rains were general over the whole of the United Kingdom, and heavy over Wales and the West Midlands, where many stations had over an inch and a half. The maximum falls reported were 2.32 in. at Llangynhafal, Denbigh; 2.05 in. at Bishops Castle; and 2.03 in. at Prestbury, Gloucestershire. At Biggar, Peebleshire, 1.75 in. fell in an hour during a thunderstorm. From the 3rd to the 15th the prevailing cyclonic type of weather was associated with local thunderstorms and heavy rains almost daily in all parts of the country. Few of the falls reported exceeded an inch and a half, but on the 11th 2.31 in. fell at Oldham, while on the 12th, at Carlisle, 2.85 in. fell, the greater part in an hour and a half. The highest temperatures of the whole month occurred on or about the 10th, but in no case reached  $80^{\circ}$  in the shade, the maxima reported being  $79^{\circ}$  at Raunds, Northamptonshire, and  $77^{\circ}$  at Greenwich, on the 10th.

On the 15th the succession of shallow depressions moving eastward over the North Sea terminated, and the weather steadily improved. Pressure during this period was in general highest off the west of Ireland, and the type markedly anti-cyclonic, although the central area of the anti-cyclone seldom covered the United Kingdom. Cool weather then prevailed till about the 23rd, the shade temperature rarely rising to  $70^{\circ}$  in any part of the country, but the last eight days were warm and sunny. In some inland situations a sharp ground frost was recorded on the 30th, and at North Cadbury Rectory the exposed minimum fell to  $31^{\circ}5$ , the first ground frost reported in August during 18 years.

Rainfall was very irregularly distributed. More than the normal fell in six patches, namely the Thames estuary, the Fen district, the North Wales border, Fife, the west of Ross, and the N.E. of Ireland. Less than half the average fell on the western coast of Scotland and in one or two isolated areas in the north and north-east, and in South Wales. In Ireland more than half the average fell everywhere. The wettest areas, with more than five inches, were in the West Highlands, the Firth of Forth, in the west of Co. Mayo, Lancashire, the Lake District, and the mountains of Central and South Wales. Less than 2 inches fell in the north and south-west coastal regions of Scotland, the south-east coast of Ireland, and generally in the east, south and south-west coastal regions of England.

In the Thames Valley the rainfall was extremely irregular and patchy, especially in the neighbourhood of London. Over the Kingdom as a whole the general rainfall expressed as a percentage of the average, was as follows: England and Wales, 72; Scotland, 68; Ireland, 83; British Isles, 75.

Sunshine was deficient, the following amounts being reported: Camden Square, 148 hours; Totland Bay, 221 hours; Copdock, 168 hours; Sidmouth, 188 hours; Ashbourne, 145 hours; Southport, 147 hours; Hull, 112 hours; Haverfordwest, 195 hours; Paisley, 116 hours; Loch Stack, 109 hours; Swinton, 111 hours; Perth, 138 hours.

In London (Camden Square), the mean temperature was  $62^{\circ}5$ , or  $0^{\circ}2$  above the average. Duration of rain, 22.3 hours. Evaporation, 1.75 inches.

## Climatological Table for the British Empire, March, 1915.

STATIONS.  (Those in italics are South of the Equator.)	Absolute.				Average.				Absolute.		Total Rain		Aver.	
	Maximum.		Minimum.		Max.	Min.	Dew Point.	Humidity.	Max. in Sun.	Min. on Grass.	Depth.	Days.		
	Temp.	Date.	Temp.	Date.										
London, Camden Square	58.5	14	26.1	29	49.0	36.0	37.0	0-100	84	97.1	22.6	.86	12	7.3
Malta ... ..	79.3	21	46.0	11	61.5	52.3	...	86	139.0	...	1.50	6	1.5	
Lagos ... ..	97.0	18, 19	73.4	25	90.6	79.3	75.2	70	157.2	72.0	2.72	5	6.3	
Cape Town ... ..	96.9	8	54.4	13	79.5	60.7	56.9	64	...	...	1.82	3	2.7	
Natal, Durban ... ..	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Johannesburg ... ..	85.6	11	44.7	22	76.1	55.0	55.1	80	...	42.2	2.64	9	3.2	
Mauritius ... ..	88.0	15	70.0	8	84.1	73.5	72.0	81	...	63.1	10.19	17	6.1	
Bloemfontein ... ..	91.1	12	40.6	21	82.2	53.9	47.5	50	..	...	1.17	4	4.0	
Calcutta... ..	95.5	23	63.9	9	89.1	69.0	66.8	70	...	53.7	4.19	9	5.1	
Bombay .. ..	92.2	21	70.5	3	86.2	73.9	70.2	74	133.0	57.1	.69	3	2.4	
Madras ... ..	97.4	26	68.8	11	90.3	74.2	72.9	77	160.5	68.2	.24	2	2.2	
Colombo, Ceylon ... ..	92.9	21	72.2	19	89.9	74.5	73.9	78	165.0	66.8	5.07	12	4.3	
Hongkong ... ..	79.8	6	54.2	17	69.2	61.0	58.2	78	...	...	2.61	11	8.0	
Sydney ... ..	100.7	8	57.7	22	78.6	65.0	57.7	64	153.9	50.9	3.40	10	5.1	
Melbourne ... ..	93.1	24	44.1	10	74.2	54.4	48.0	53	143.0	35.0	.25	6	5.3	
Adelaide ... ..	97.3	11	49.4	22	79.2	57.9	47.5	38	152.5	37.5	.24	3	3.8	
Perth ... ..	97.0	4	49.9	19	79.4	60.1	54.5	59	156.9	41.7	1.61	10	3.5	
Coolgardie ... ..	97.2	5	48.0	19	82.5	57.3	50.5	48	154.4	43.8	.35	4	1.8	
Hobart, Tasmania ... ..	85.8	24	43.3	29	66.2	50.4	44.7	63	136.1	34.1	2.43	12	6.6	
Wellington ... ..	69.6	21	42.6	7	62.0	52.5	50.9	81	139.4	32.0	4.61	17	7.6	
Auckland ... ..	74.0	16	49.0	9	67.7	55.8	55.3	80	142.0	45.0	7.27	17	5.4	
Jamaica, Kingston ... ..	89.7	26	67.3	10	87.4	70.5	69.0	77	...	...	.58	5	3.8	
Grenada ... ..	88.0	5+	71.0	27	85.0	74.3	...	70	136.0	...	1.02	4	2.0	
Toronto ... ..	49.0	23, 24	10.6	30	37.5	22.4	21.3	76	116.7	7.0	.84	6	4.3	
Fredericton ... ..	...	...	...	...	...	...	...	...	...	...	...	...	...	...
St. John, N. B. ... ..	52.0	25	9.0	27	35.5	21.8	19.0	67	...	...	.41	7	6.0	
Alberta, Edmonton ... ..	62.3	21	7.8	3	41.5	21.1	...	74	119.0	1.0	.10	4	5.2	
Victoria, B.C. ... ..	66.2	21	38.0	8	54.3	42.9	...	77	...	29.9	1.53	16	6.1	

\* also 14 and 17.

† also 6 and 11.

*Johannesburg.*—Bright sunshine 269.7 hours.*Mauritius.*—Mean temp. 0°.9, dew point 1°.1, and R .90 in. above, averages. Mean hourly velocity of wind 0.5 miles above average.*Bloemfontein.*—The driest March on record; very warm month.

COLOMBO, CEYLON.—Mean temp. 82°.2 or 0°.6 above, dew point 1° above, and R 1.33 in. above, averages. TS on 5 days, distant T and L on 14 days.

HONGKONG.—Mean temp. 64°-9. Mean hourly velocity of wind 13.0 miles. Bright sunshine 115.7 hours.

*Sydney.*—Highest max. temp. for March on record.*Melbourne.*—Mean temp. 0° below, and R 1.97 in. below, averages.*Adelaide.*—Very dry throughout the State.*Coolgardie.*—Temp. 1°-7 below, and R .25 in. below, averages.*Hobart.*—Rainfall .78 ins. above, and mean temp. 1°-3 below, averages.*Wellington.*—Mean temp. 3°-2 below, and R 1.21 in. above, averages. Bright sunshine 136.7 hours.*Auckland.*—Rainfall considerably above, and mean temp. below, averages.

JAMAICA, KINGSTON.—R one-third of the average.

ALBERTA, EDMONTON.—Sunny, dry and very warm; frosts on 28 nights.