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ILLUSIONS OF THE UPPER AIR.

Summary of a Lecture at the Royal Institution on Friday, March 10th, 1916, by Sir Napier Shaw, Sc.D., F.R.S.

The lecture was made an occasion for reviewing the progress of meteorological theory in England in the half century that has elapsed since the Meteorological Committee of the Royal Society was appointed to control the Meteorological Office.

The programme of the reconstituted Office was to continue the study of the Meteorology of the sea, and the collection and distribution of daily telegraphic reports of weather and to apply the automatic records of a number of observatories similar to the New Observatory at Richmond to the interpretation of the observed facts of weather After referring to the activity in the study of weather, and particularly in devising weather charts, which was displayed in the early sixties by FitzRoy at the Meteorological Department of the Board of Trade, by G. J. Symons and James Glaisher, who were interested in British Rainfall and Climatology, and by Francis Galton, who was one of the leading spirits of the British Association and of Kew Observatory, a statement was given of the convection theory of the structure of the atmosphere in relation to cyclones and anticyclones which was generally accepted at the time and for years afterwards. It was pointed that the ideas about cyclones and anticyclones were at the time necessarily speculative, and it was proposed to confront them with the structure of the atmosphere as disclosed by the investigation of the upper air with kites, ballons-sondes and pilot balloons during the last twenty years. Illustrations of the general results of the investigation were exhibited; and the separation of the atmosphere into the troposphere, the region of convection and the stratosphere, the region of no convection, was explained.

The guiding principle of the convection theory was that air flowed from a centre of high pressure (anticyclone) where cold air was descending, into a centre of low pressure (cyclone) where warm air was ascending. The double spiral paths by which the air proceeds from an anticyclone centre towards a cyclonic centre were commonly

regarded as lines of natural flow from high to low contorted by the rotation of the earth.

The observations of the upper air have shown that this mode of representation is illusory in every essential item; the mistake arose from taking the characteristics peculiar to the surface to be generally representative.

The convergence of the air along the spiral paths is shown to be largely illusory when the facts are carefully examined. Above the first half kilometre the inflow towards the low pressure cannot be identified at all.

Instead of assuming an inflow which cannot be proved it is better, there and elsewhere throughout the upper air, to assume the circulation to be represented by the "uniform" flow of air along the isobars under balanced "forces" arising from the distribution of pressure on the one hand, and the rotation of the earth and the circular path of the air on the other. Instead of a natural flow from high pressure to low pressure we have a natural flow without any change of pressure; the motion of a heavenly body round its sun is taken as the type for the air instead of the motion of a falling stone. The cross flow that is to be found near the surface should be attributed to the friction of the surface reducing the speed of the moving air, below that which is necessary to balance the pressure. Thus the friction which seemed to be an obstacle to the flow across isobars must really be regarded as its cause.

The idea of convective force operating as an upward force in the "low" with a corresponding force in the "high" is shown to be illusory by observations which prove that the air in the high pressure is warmer than that at the same level in the low. The formation of high and low pressure at the surface proceeds therefore *in spite of* a distribution of temperature which opposes it, not *because of* a distribution of temperature which favours it. Nor is the humidity of the air of any importance in forming low pressure. The distribution of pressure at the surface has been shown to be the distribution at a height of 9 kilometres transmitted from above with local changes caused by the varying density of the lower layers.

From the idea of the operation of the varying pressure of the stratosphere upon the troposphere interesting deductions were drawn as to the formation and transformation of different types of cloud. These were followed by a number of numerical calculations of the relation between pressure, temperature, and wind, at different levels which are rendered possible by the fundamental numerical relation between pressure and wind velocity. Two forms of the relation are considered, (1) the geostrophic relation in which air is regarded as moving along a great circle and the effect is entirely due to the rotation of the earth; this is taken as applicable in temperate and polar latitudes. And (2) the cyclostrophic relation

in which the effect of the rotation of the earth is disregarded altogether, and attention is concentrated upon motion in a small circle. The second case is applicable in the equatorial regions, in tropical revolving storms and other circulations of small diameter.

By means of these two equations combined with the ascertained facts of the upper air are explained (1) the absence of strong winds in the central region of an anti-cyclone; (2) the dominance of the stratosphere on the distribution of pressure at the surface; (3) the apparently capricious variations of temperature and wind velocity at different levels; (4) the conditions of application of "Egnell's law" of the flow of equal masses of air at different levels; (5) the falling off of the velocity of wind in the stratosphere; (6) the changes of wind velocity with height in the troposphere, and (7) the maintenance of a cylindrical vortex with its foot on the ground covered by a cap of limited height in the stratosphere.

The lecture concluded with a fantastic but circumstantial suggestion that the Medusa of Greek myth has a subtle reference to the relation of fact to theory in the study of weather.

JANUARY AND JUNE—A CONTRAST.

THE poet, by way of an extravagant compliment, refers to the coming of his lady as making December June, and perhaps the simile would have been improved in its climatic antithesis as well as in alliteration by making "January June," for indeed in the south of England a day in January is on the average 21 degrees colder than a day in June. This year the poetic metaphor would be deprived of its beauty and return like a boomerang to confute the poet. In our February number we referred to the extraordinary warmth of January 1st, now we note the extraordinary cold of June 4th. The temperature readings at Camden Square on these days were :—

	Max.	Min.	9 hr.	21 hr.	Mean per day
	°	°	°	°	°
Jan. 1	57·2	47·2	52·8	51·4	52·2
June 4	56·9	42·7	54·2	53·0	51·7
Difference, June—Jan.	−0·3	−4·5	+1·4	+1·6	−0·5

Thus the 4th of June was half a degree colder on the whole than the 1st of January, and the June night 4½ degrees colder than the January night, a satire on the solstitial control of the seasons.

ROYAL METEOROLOGICAL SOCIETY.

A MEETING of the Society was held in its rooms, 70, Victoria Street, on May 17th, Major H. G. Lyons, F.R.S., in the Chair. Mr. L. C. W. Bonacina read a paper on the Re-adjustment of Pressure Differences : Two Species of Atmospheric circulation and their connection. He said that in ordinary events slightly rarified air, however the reduction in density may be caused, will rise and overflow with marked exaggeration of the original decrease of pressure, so that cyclonic circulation automatically develops under the influence of the Earth's rotation. The air will always try to adjust the pressure difference by the open road of cyclonic or "horizontal" circulation provided that the atmosphere is not in a special state of "strain" occasioned by the exigencies of the existing circulation. But when this condition of strain or instability exists, the air chooses a short cut, and adjusts the original slight pressure difference locally by the thunderstorm or "vertical" method. Thus a thunderstorm should be regarded as acting after the manner of a safety-valve, whereby undue development of cyclonic energy is obviated, Thunderstorms occur when the atmospheric signals are set against the course which leads to the development, or further development, of horizontal gradient-winds around a barometric minimum; the physical reason being that the atmosphere, being then unstable, or strained, in consequence of the obstacle to cyclonic development, but the pressure balance having to be restored somehow, chooses a course which obviates the need of cyclonic circulation, and which does not involve such resistance in the general body of the atmosphere to the density-equalizing action of gravity as would be the case if it ultimately overcame the said obstacle, and cyclonic energy were thus to develop uncontrolled.

The following is a synopsis of the cardinal points :—

1. The essential condition that circulation of any description may be started in the free atmosphere is slight variation of density.

2. It is found that while sometimes such variations of density lead to a species of circulation in which horizontal motion takes precedence over vertical and whose very development leads to the awkward circumstance that the difference of pressure becomes much greater than the original; at other times such variations of density are suddenly nullified, or disposed of, by another species of circulation in which horizontal movement is subordinate to vertical.

3. This at once raises the question of a dynamical relationship between the two modes of motion, the connection being illustrated by a consideration of what would happen if the second type had no existence.

4. The connection being established, a theory of "wave" transmission suggested by certain facts of observation was devised in order to explain *how* the two species of circulation are connected and to furnish a picture of the manner in which one is limited by the other.

5. This hypothesis requires testing by an application to the facts of detailed observation; but as it now stands it leads to the inference that the momentum of the atmosphere is assorted between the two species of motion, and that the total upward momentum is the same whether a *given area* becomes the centre of uniform cyclonic energy, or becomes split up into local patches of concentrated energy arranged along one or more alignments.

6. The principle of the connection brought to light also accounts for the fact that the two species of storm-action are opposite in their seasonal range, cyclonic gales occurring in the depth of winter and thunderstorms at the height of summer—at least in such a climatic belt as that in which Britain lies.

An animated discussion followed the reading of the paper.

The Chairman regretted that the author had not applied rigorous mathematical treatment to the problem.

Mr. W. H. Dines pointed out that upper air observations had shown that the air in a cyclone was relatively cold, probably because it was being forced to ascend whereas thunderstorms were probably convectional phenomena, the two systems of circulation being different in kind.

Major G. I. Taylor, speaking as an aviator, described a recent experience in which both rapidly ascending and rapidly descending currents had been encountered at a height of about 10,000 feet.

Mr. F. J. W. Whipple said that the author was probably right in drawing a sharp line of demarcation between the two types of disturbance, the cyclone and the summer thunderstorm, but that winter thunderstorms were generally incidents in the passage of cyclonic depressions.

Col. H. E. Rawson pointed out that the effect of the accompanying anti-cyclone should be considered in connection with cyclonic movements.

Dr. H. R. Mill welcomed the paper as an attempt to explain the difference between two contrasted atmospheric conditions, and deprecated the tendency to undervalue the part of the imagination in the scientific method of reasoning.

Mr. W. W. Bryant suggested as an analogy to Mr. Bonacina's idea, the fact that a weak electric current would pass around a spirally coiled wire, while a stronger current would overcome the intervening resistance and leap from coil to coil.

Mr. Bonacina in reply stated that he had only begun consideration of the subject, and hoped later to develop it mathematically.

SUMMER TIME AND METEOROLOGY.

THE Summer Time Act was rushed through Parliament so quickly that our remarks on the subject last month had to be based on the Bill as introduced, if they were to be in time to warn Observers as to the course they should follow on the appointed day. At a later stage a very important amendment was introduced. Meteorology, as well as Astronomy and Navigation was expressly exempted from the provisions of the Act. This is a valuable concession, as it relieves the meteorological Observer from committing an illegal act by calling 9 o'clock "9 o'clock" when he is referring to meteorological work. But mature reflection shows that the advantage is largely illusory, because although Meteorology stands without the Act the meteorologist remains subject to its sway when he requires to take his breakfast or catch a train. So far as the Meteorological Office instructions go the Observer must observe two times instead of one, and he is officially instructed to keep two clocks, one running to the mean solar time of 0°, the other to that of 15° E. By the former he must make his observations and remarks on meteorological phenomenon, and by the latter he may regulate the less important duties of life. The Meteorological Office suggests that Greenwich mean time should be expressed in hours counted consecutively from 0 at midnight to 24 at the next midnight, so that what used to be 9 p.m. becomes 21 hrs. 0 min. This is a reform which was introduced more than thirty years ago, and the present writer has used it in scientific records and diagrams since 1884, but he found himself almost alone in the practice. We very cordially welcome the change in the official weather service of the country. It goes towards simplification and introduces no ambiguity or difficulty as new units usually do. The advice to use a.m. and p.m. in giving the hours in Summer Time should serve to mark the difference; the fact that the noon referred to is that of Berlin need not cause the patriot to shudder at the change, because in Germany and its subject lands the noon of Petrograd is used to set the summer clock.

The denomination of time has always given rise to confusion in non-scientific minds, and the new legislation does not tend to improve matters. Even when observations are made at the right hour, we fear that many Observers will fail to indicate this so as to place the fact beyond doubt. Let us repeat the new rule for rainfall Observers :—

Read the rain gauge at 10 a.m., Summer Time, and enter the hour as 9 a.m.

to which we must add—remember that on and after October 1st clock-time and Greenwich (or Dublin, as the case may be) time are at one again and revert to 9 o'clock readings.

Correspondence.

To the Editor of Symons's Meteorological Magazine.

SUMMER TIME.

I READ your remarks *re* Prussian Time with interest. Taking the attitude of a higher critic, I surmise that your school boy was a fifth or sixth form boy at a public school, or, if a Sunday school boy—then an American; and that the true version of what he said is "A lie is an abomination to the Lord, but a very present help in trouble." I quite agree with all your comment thereon. Would it not be possible another year, if the war goes on, to have a new Bradshaw brought out early in May, to open Banks as now, and leave the clocks alone? The practical conveniences of the present arrangements are so great, and the working of them has come about so smoothly, that people in general quite fail to see the viciousness in principle of the short and easy method that has been chosen. It is deplorable that they should think that Time questions come within the scope of a British Parliament, or can be dealt with satisfactorily by anything less than a Parliament (rather a "Church") of experts representing the whole civilized world. I hope you will try to influence public opinion in this sense. It seems to me that the plot was sprung on us by a secret cabal and pushed through without time given for consideration. And then the change was meekly accepted by that public which has for fifty years, like an obstinate mule, refused to do anything to improve in practice our cumbrous system of weights and measures which lies like a dead weight on the elementary schools, and wastes who knows how much time and energy?

H. A. BOYS.

North Cadbury Rectory, Somerset, June 7th, 1916.

THE ATMOSPHERIC SHADES OF MAY.

IF May were merely the month of the greatest profusion of blossom in the year it would be beautiful enough, but when the meteorological conditions are such that all this wealth of flower and fresh foliage is thrown into relief by richly coloured and exquisitely blended atmospheric shades and hues of a kind which are entirely peculiar to the early summer, the effect is enchanting beyond words.

May's own quality of sky, light, and shade is of two kinds. Firstly, there is the cold, damp, stagnant, very gloomy type of day which almost invariably occurs once or twice in the early part of May, and on which the new foliage looms out with a vividness unknown on bright days. This type of atmosphere is in reality extremely beautiful, but its beauty is beyond the perception of some people

who may be heard to liken it to a "November fog." Secondly, and this is May's supreme revelation of meteorological beauty—there are the richly-hued thundery days which are in evidence on several occasions every year, but are not seen during the spells of thundery weather which occur during the following summer months. Picture, as an instance of the climatic phase I mean, a still, hot, steamy evening in the fragrance of full hawthorn-tide, where the landscape is suffused with delicate tints of rose and purple, when the shaggy elms are superbly silhoutted against a black eastern sky, and great banks of dark-flanked cumulus hang motionless in the western light, the atmosphere but too evidently—to those who know the wiles of the English climate—awaiting the morrow's heat for the development of those violent electrical storms for which the Merry Month has a somewhat bad reputation.

With regard to these peculiar atmospheric shades the May of 1916 was quite typical, and with regard to the general character of the weather the second half of the month, as is so often the case, was high summer, although it was only on one day, the 21st, that the heat was really severe. The month opened in a thunder spell, and, as is nearly always the case, closed in one, the storm of the 30th being specially destructive in the West of Ireland, a part of the country which normally suffers comparatively little from the violence of summer hail and thunder.

L. C. W. BONACINA.

Hampstead, N.W., June 1st, 1916.

RAPID RISE IN A CHALK WELL.

FOLLOWING upon my communications to your Magazine for 1915 (vol. **50,** pp. 16, 46) upon the subject of the rise of water in the well at Chelsham in 1914-15, I am now sending you these observations in diagram form, together with those for the corresponding period in 1915-16.

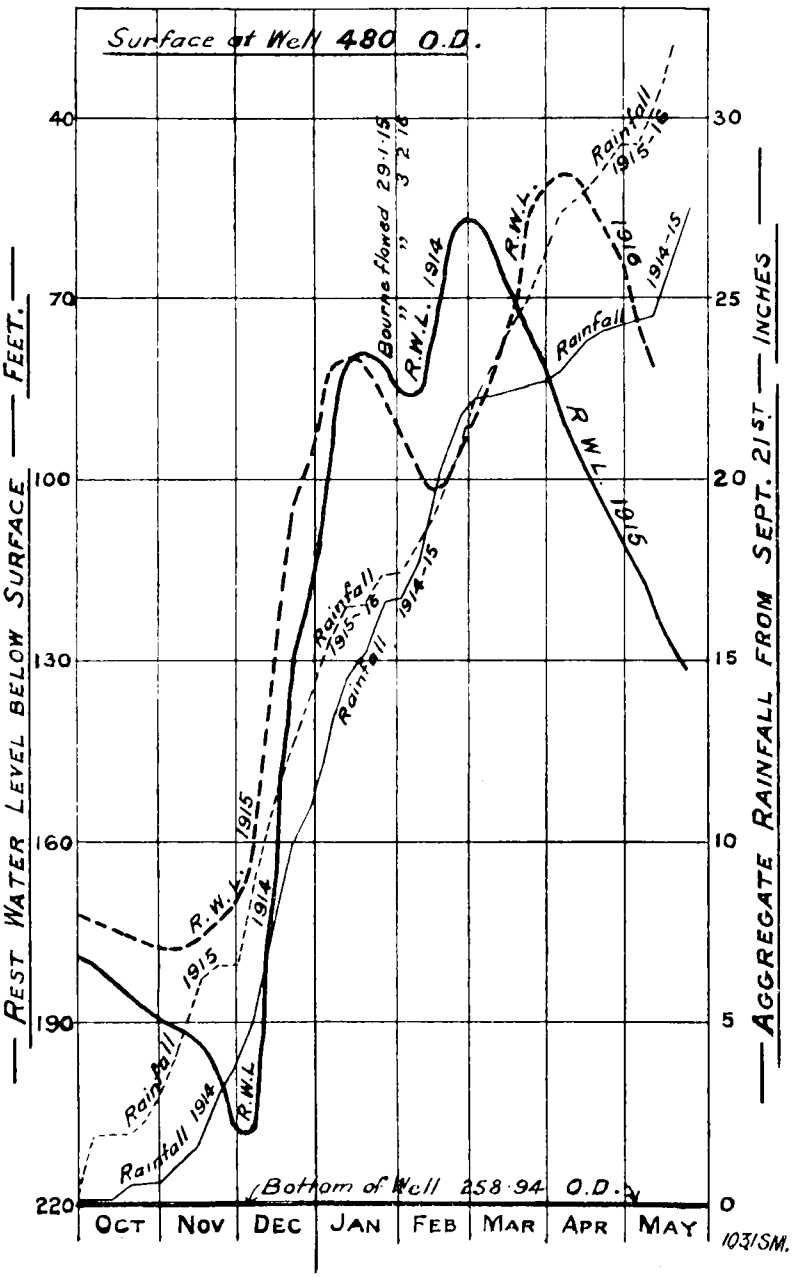
The records are very instructive and may, I think, be of interest to your readers. They show the relation between the depth of the water in the well and the rainfall, and how the appearance of the Bourne affects the height of the underground water. That the flow of the Bourne should release the water pent up in the ground and thus reduce its level is easy to understand, but why the water in the well should fall *before* the Bourne begins to flow, is not so clear. The diagram also shows that the spring rainfall, owing, no doubt, to evaporation then becoming active, does nothing to replenish the well.

W. VAUX GRAHAM.

5, Queen Anne's Gate, London, S.W., May 30th, 1916.

WELL AT CHELSHAM. SURREY.

DIAGRAM OF REST WATER LEVEL & RAINFALL OCTOBER – MAY 1914-15 & 1915-16.



HEAVY THUNDERSTORM, MAY 30th.

We had here, on Tuesday, May 30th, about 0·29 p.m., old time, a very heavy thunderstorm which passed right over us from west to east. The fall of rain and hail was quite tropical. In 50 minutes 1·12 in. had fallen into the gauge. Much damage was done to gardens, young seedlings and plants being washed clean out of the ground. Some damage was also done to the roads in places, and the passage and booking-office at the northern approach to Hither Green railway station was flooded out. The thunder and lightning was very sharp, but not so severe as in the storms of May, 1911, and June, 14th, 1914.

G. E. DACEY.

Lewisham, S.E., June 12th, 1916.

METEOROLOGICAL NEWS AND NOTES.

The South Orkneys Meteorological Observers returned to Buenos Aires on March 20th, the Argentine Government having relieved them by a new party (all Scandinavians) to continue the work during the present year. We regret to learn that Mr. H. Basche-Wiig, chief of last year's party lost his life on April 30th, 1915, when ski-ing on the east glacier at Laurie Island, where he was blown over the ice cliff into the sea and drowned. Mr. Basche-Wiig was a lieutenant in the Norwegian Navy and previous to his departure for the South Orkneys in February 1915 was first assistant at the Argentine Central Magnetic Observatory at Pilar. The returning party describe the winter of 1915 as having been the roughest since the station was established in 1903. No precise information regarding the ice and weather conditions during last summer has yet come to hand. No difficulty was experienced by the Argentine relief ship in reaching the South Orkney group (Lat. 61° S.) at the beginning of March. The extremes of temperature noted were 45° F. in January 1916, and -27° F. in June, 1915, both values being in close agreement with the normals of the preceding twelve years.

British Rainfall, 1915, is now approaching completion and any Observers who have not yet sent in their returns for 1915, are requested to do so without delay.

Mr. R. F. Stupart, Director of the Canadian Meteorological Service has, we are pleased to observe, received the honour of knighthood on the occasion of the King's Birthday. We heartily congratulate Sir Robert Stupart on this public recognition of his services.

REVIEWS.

Department of Marine and Fisheries, Meteorological Service of Canada. Upper Air Investigation in Canada, Part I. Observations by Registering Balloons. Prepared under the Direction of R. F. STUPART, F.R.S.C., by J. PATTERSON, M.A., Ottawa, 1915. Size, 10 × 6½. Pp. 128.

THIS gives a summary of the work carried on on the upper air by means of balloons in Canada.

The report shows that ninety-four balloons were sent up from Toronto, or Woodstock, between January, 1911, and May, 1915, Fifty-three were recovered, and the results of their records worked out and published at length in this report. In one case the balloon was found thirteen months after being sent up, the record still being quite legible. The balloons were usually sent up about 8 p.m. on the evening preceding the international day, that is to say about six hours earlier than the European ascents, and with the advantage of avoiding disturbance by solar radiation.

Most of the balloons travelled in an easterly direction from the point of departure, only three having been found to the west. The height reached by the balloons in winter was less than in summer in the ratio of 12:15, and the lower level of the stratosphere was found to be at an average height of 11·4 km. (6·3 miles) in winter and 13·4 km. (8·4 miles) in summer. The stratosphere has a lower temperature in summer than in winter, the average of eleven flights in summer showing —62°·3 C. (—80° F.), and twelve flights in winter showing —59° C. (—74° F.).

Observatoire de Zi-ka-Wei. Calendrier-Annuaire pour 1916, [*Observatory of Zi-ka-Wei Calendar Year Book for 1916.*] Zi-ka-Wei, near Shanghai, 1915. Size 6 × 3½. Pp. 174 + 72*. Plates.

THE Year Book of this famous observatory is naturally concerned mainly with astronomical data for China; but it also contains some interesting meteorological matter, the most important being a concise statement of the climate of Zi-ka-Wei with normal values for 10 day groups, based on the period 1873-1905, and a more detailed discussion of the climate of China month by month under the heads of barometric pressure, wind, fog and rain, temperature being left for treatment in a later year. There is also a meteorological diary for the year July 1914 to June 1915, and there are tabular appendices containing, amongst other things, conversion tables for the various ancient and modern units of measurement used in China and in the Western World.

RAINFALL TABLE FOR MAY, 1916.

STATION.	COUNTY.	Lat. N.	Long. W. [*E.]	Height above Sea. ft.	RAINFALL OF MONTH. Aver. 1875—1909. in.	1916. in.
		° ′	° ′			
Camden Square	*London*	51 32	0 8	111	1·75	1·88
Tenterden	*Kent*	51 4	*0 41	190	1·65	1·82
Arundel (Patching)	*Sussex*	50 51	0 27	130	1·80	1·86
Fordingbridge (Oaklands)	*Hampshire*	50 56	1 38	135	2·09	2·12
Oxford (Magdalen College)	*Oxfordshire*	51 45	1 15	186	1·81	1·83
Wellingborough (Swanspool)	*Northampton*	52 18	0 41	155	1·98	1·93
Bury St. Edmunds (Westley)	*Suffolk*	52 15	*0 40	226	1·93	1·69
Geldeston [Beccles]	*Norfolk*	52 27	*1 31	38	1·78	...
Polapit Tamar [Launceston]	*Devon*	50 40	4 22	315	2·08	1·51
Rousdon [Lyme Regis]	,,	50 41	3 0	516	2·02	2·17
Stroud (Field Place)	*Gloucestershire*	51 44	2 13	226	2·10	3·10
Church Stretton (Wolstaston)	*Shropshire*	52 35	2 48	800	2·64	3·02
Boston	*Lincolnshire*	52 58	0 1	11	1·80	1·75
Worksop (Hodsock Priory)	*Nottinghamshire*	53 22	1 5	56	2·08	2·48
Mickleover Manor	*Derbyshire*	52 54	1 32	280	2·10	2·33
Macclesfield	*Cheshire*	53 15	2 7	501	2·43	3·57
Southport (Hesketh Park)	*Lancashire*	53 39	2 59	38	2·13	2·45
Arncliffe Vicarage	*Yorkshire, W.R.*	54 8	2 6	732	3·55	2·99
Goldsborough Hall	,, ,,	54 0	1 25	119	2·16	2·50
Hull (Pearson Park)	,, *E.R.*	53 45	0 20	6	1·98	2·79
Newcastle (Town Moor)	*Northumberland*	54 59	1 38	201	2·04	2·80
Borrowdale (Seathwaite)	*Cumberland*	54 30	3 10	423	7·50	8·35
Cardiff (Ely)	*Glamorgan*	51 29	3 13	53	2·56	4·01
Haverfordwest	*Pembroke*	51 48	4 58	90	2·62	2·92
Aberystwyth (Gogerddan)	*Cardigan*	52 26	4 1	83	2·63	5·73
Llandudno	*Carnarvon*	53 20	3 50	72	1·86	3·60
Cargen [Dumfries]	*Kirkcudbright*	55 2	3 37	80	2·87	4·50
Marchmont House	*Berwick*	55 44	2 24	498	2·53	3·10
Girvan (Pinmore)	*Ayr*	55 10	4 49	207	2·98	4·72
Glasgow (Queen's Park)	*Renfrew*	55 53	4 18	144	2·40	...
Islay (Eallabus)	*Argyll*	55 47	6 15	68	2·58	5·00
Mull (Quinish)	,,	56 34	6 13	35	2·99	4·10
Balquhidder (Stronvar)	*Perth*	56 21	4 23	422	4·10	...
Dundee (Eastern Necropolis)	*Forfar*	56 28	2 57	199	2·05	3·73
Braemar	*Aberdeen*	57 0	3 24	1114	2·33	2·37
Aberdeen (Cranford)	,,	57 8	2 7	120	2·40	3·49
Gordon Castle	*Moray*	57 37	3 5	107	2·10	4·41
Drumnadrochit	*E. Inverness*	57 20	4 29	138	2·33	4·52
Fort William	,, ,,	56 49	5 6	171	3·93	4·27
Loch Torridon (Bendamph)	*W. Ross*	57 32	5 32	20	4·54	4·62
Dunrobin Castle	*Sutherland*	57 59	3 56	14	2·19	3·57
Killarney (District Asylum)	*Kerry*	52 4	9 31	178	3·05	4·03
Waterford (Brook Lodge)	*Waterford*	52 15	7 7	104	2·33	3·88
Nenagh (Castle Lough)	*Tipperary*	52 54	8 24	120	2·51	2·78
Ennistymon House	*Clare*	52 57	9 18	37	2·70	3·26
Gorey (Courtown House)	*Wexford*	52 40	6 13	80	2·24	3·61
Abbey Leix (Blandsfort)	*Queen's County*	52 56	7 17	532	2·43	5·10
Dublin (FitzWilliam Square)	*Dublin*	53 21	6 14	54	2·07	4·63
Mullingar (Belvedere)	*Westmeath*	53 29	7 22	367	2·51	4·75
Crossmolina (Enniscoe)	*Mayo*	54 4	9 16	74	3·17	4·63
Cong (The Glebe)	,,	53 33	9 16	112	2·94	4·83
Collooney (Markree Obsy.)	*Sligo*	54 11	8 27	127	2·80	4·89
Seaforde	*Down*	54 19	5 50	180	2·72	6·07
Ballymena (Harryville)	*Antrim*	54 52	6 13	150	2·84	6·43
Omagh (Edenfel)	*Tyrone*	54 36	7 18	280	2·66	5·40

RAINFALL TABLE FOR MAY, 1916—*continued.*

RAINFALL OF MONTH (*con.*)					RAINFALL FROM JAN. 1.					
Diff. from Av. in.	% of Av.	Max. in 24 hours. in.	Max. in 24 hours. Date.	No. of Days	Aver. 1875—1909. in.	1916. in.	Diff. from Aver. in.	% of Av.	Mean Annual 1875-1909, in.	STATION.
+ ·13	107	·32	8	13	8·68	12·62	+3·94	145	25·11	Camden Square
+ ·17	105	·38	12	12	9·41	12·48	+3·07	133	27·64	Tenterden
+ ·06	103	·39	2	10	10·33	14·10	+3·77	137	30·48	Patching
+ ·03	101	·82	1	15	11·11	12·94	+1·83	116	31·06	Fordingbridge
+ ·02	101	·41	12	18	8·33	12·76	+4·43	153	24·58	Oxford
— ·05	97	·56	12	14	9·08	12·25	+3·17	135	25·20	Swanspool
— ·24	88	·51	12	12	8·55	12·59	+4·04	147	25·40	Westley
...	...	...	...	...	7·84	...	...	...	23·73	Geldeston
— ·57	73	·36	7	18	13·70	15·78	+2·08	115	38·27	Polapit Tamar
+ ·15	107	·51	1	17	12·15	13·32	+1·17	110	33·54	Rousdon
+1·00	148	·48	24	20	10·65	13·46	+2·81	126	29·81	Stroud
+ ·38	114	·50	4	17	11·71	13·85	+2·14	118	32·41	Wolstaston
— ·05	97	·35	9	15	7·91	12·36	+4·45	156	23·35	Boston
+ ·40	119	·74	12	13	8·74	11·57	+2·83	132	24·46	Hodsock Priory
+ ·23	111	·57	4	18	9·22	15·07	+5·85	164	26·65	Mickleover
+1·14	132	1·31	6	12	11·91	15·04	+3·13	121	34·73	Macclesfield
+ ·32	115	·60	12	16	10·70	11·19	+ ·49	105	32·70	Southport
— ·56	84	·71	4	10	23·59	26·43	+2·84	112	61·49	Arncliffe
+ ·34	116	·67	4	12	9·71	12·27	+2·56	127	27·29	Goldsborough Hall
+ ·81	140	·54	4	10	8·99	11·55	+2·56	128	26·42	Hull
+ ·76	137	·72	4	16	9·51	11·57	+2·06	122	27·94	Newcastle
+ ·85	111	4·50	31	12	49·44	58·98	+9·54	119	129·48	Seathwaite
+1·45	157	1·18	24	21	14·67	19·06	+4·39	130	42·28	Cardiff
+ ·30	111	·35	8	19	16·71	15·68	—1·03	94	46·81	Haverfordwest
+3·10	218	1·63	24	22	15·15	20·23	+5·08	134	45·46	Gogerddan
+1·74	193	·68	24	21	10·40	13·29	+2·89	128	30·36	Llandudno
+1·63	157	·84	31	21	16·22	20·53	+4·31	127	43·47	Cargèn
+ ·57	122	·69	5	20	12·00	16·65	+4·65	139	33·76	Marchmont
+1·74	158	·82	5	20	18·06	21·64	+3·58	120	49·77	Girvan
...	...	...	...	...	13·10	...	...	...	35·97	Glasgow
+2·42	194	·75	31	23	17·59	25·41	+7·82	145	48·79	Eallabus
+1·11	137	1·05	31	22	20·25	20·01	— ·24	99	56·57	Quinish
...	...	...	...	...	29·34	...	...	...	73·77	Stronvar
+1·68	182	1·04	5	18	9·96	12·47	+2·51	125	28·64	Dundee
+ ·04	102	·76	5	16	12·97	19·12	+6·15	148	34·93	Braemar
+1·09	146	1·17	5	15	12·00	10·92	—1·08	91	32·73	Aberdeen
+2·31	211	·84	6	21	10·14	14·00	+3·86	138	30·34	Gordon Castle
+2·19	194	·92	5	17	13·79	23·05	+9·26	162	36·13	Drumnadrochit
+ ·34	109	1·55	31	24	30·02	37·51	+7·49	125	75·80	Fort William
+ ·08	102	1·18	31	20	33·48	40·74	+7·26	122	83·93	Bendamph
+1·38	164	·48	2, 7	19	12·18	16·33	+4·15	134	31·90	Dunrobin Castle
+ ·98	132	·87	5	22	21·95	23·85	+1·90	109	54·81	Killarney
+1·55	166	1·39	5	19	14·61	14·85	+ ·24	102	39·57	Waterford
+ ·27	111	·90	5	18	14·81	17·55	+2·74	118	39·43	Castle Lough
+ ·56	121	·47	6	21	16·49	20·49	+4·00	124	46·52	Ennistymon
+1·37	161	1·42	5	17	12·83	15·37	+2·54	120	34·99	Courtown Ho.
+2·67	210	1·28	5	18	13·26	16·43	+3·17	124	35·92	Abbey Leix
+2·56	228	1·82	5	21	10·15	14·64	+4·49	145	27·68	Dublin
+2·24	189	1·58	5	18	13·29	18·91	+5·62	142	36·15	Mullingar.
+1·46	146	·75	5	24	20·21	26·16	+5·95	129	52·87	Enniscoe
+1·89	164	·91	31	21	18·23	22·74	+4·51	125	48·90	Cong
+2·09	173	·74	31	23	15·72	21·15	+5·43	134	42·71	Markree
+3·35	223	1·62	5	19	14·54	17·09	+2·55	118	38·91	Seaforde
+3·59	227	1·49	25	19	15·20	20·99	+5·79	138	40·84	Ballymena
+2·74	203	·81	4	22	14·28	19·35	+5·07	135	39·38	Omagh

SUPPLEMENTARY RAINFALL, MAY, 1916.

Div.	STATION.	Rain inches.	Div.	STATION.	Rain inches.
II.	Warlingham, Redvers Road	3·49	XI.	Lligwy	4·52
,,	Ramsgate	1·75	,,	Douglas	5·86
,,	Hailsham	2·44	XII.	Stoneykirk, Ardwell House	6·28
,,	Totland Bay, Aston House	1·84	,,	Carsphairn Shiel	4·67
,,	Stockbridge, Ashley	1·27	,,	Beattock, Kinnelhead	5·57
,,	Grayshott	1·88	,,	Langholm, Drove Road	3·90
III.	Harrow Weald, Hill House	1·90	XIII.	Selkirk, The Hangingshaw	4·59
,,	Pitsford, Sedgebrook	1·90	,,	North Berwick Reservoir	2·84
,,	Woburn, Milton Bryant	1·70	,,	Edinburgh, Royal Observaty.	3·36
,,	Chatteris, The Priory	1·44	XIV.	Maybole, Knockdon Farm	3·60
IV.	Elsenham, Gaunts End	1·88	XV.	Buchlyvie, The Manse	4·35
,,	Shoeburyness	1·38	,,	Ballachulish House	4·98
,,	Colchester, Hill Ho., Lexden	1·68	,,	Oban	4·60
,,	Ipswich, Rookwood, Copdock	1·81	,,	Campbeltown, Witchburn	4·83
,,	Aylsham, Rippon Hall	2·24	,,	Holy Loch, Ardnadam	6·90
,,	Swaffham	2·02	,,	Tiree, Cornaigmore	4·00
V.	Bishops Cannings	1·56	XVI.	Dollar Academy	...
,,	Wimborne, St. John's Hill	1·83	,,	Glenlyon, Meggernie Castle	5·13
,,	Ashburton, Druid House	2·01	,,	Blair Atholl	3·60
,,	Cullompton	2·94	,,	Coupar Angus	3·53
,,	Lynmouth, Rock House	2·25	,,	Montrose, Sunnyside Asylum.	2·83
,,	Okehampton, Oaklands	2·24	XVII.	Alford, Lynturk Manse	3·92
,,	Hartland Abbey	1·77	,,	Fyvie Castle	4·70
,,	Probus, Lamellyn	...	,,	Keith Station	4·11
,,	North Cadbury Rectory	2·13	XVIII.	Rothiemurchus	3·69
VI.	Clifton, Stoke Bishop	3·93	,,	Loch Quoich, Loan	9·30
,,	Ledbury Underdown	2·94	,,	Skye, Dunvegan	5·02
,,	Shifnal, Hatton Grange	2·77	,,	Lochmaddy, Bayhead	3·59
,,	Droitwich	2·49	,,	Fortrose	3·54
,,	Blockley, Upton Wold	2·93	,,	Glencarron Lodge	5·51
VII.	Market Overton	...	XIX.	Altnaharra	4·02
,,	Market Rasen	2·68	,,	Melvich	3·06
,,	Bawtry, Hesley Hall	2·16	,,	Loch More, Achfary	4·56
,,	Derby, Midland Railway	1·92	XX.	Dunmanway, The Rectory	3·46
,,	Buxton	2·47	,,	Glanmire, Lota Lodge	3·26
VIII.	Nantwich, Dorfold Hall	2·06	,,	Mitchelstown Castle	3·18
,,	Chatburn, Middlewood	3·06	,,	Darrynane Abbey	...
,,	Lancaster, Strathspey	3·54	,,	Clonmel, Bruce Villa	3·60
IX.	Langsett Moor, Up. Midhope	2·40	,,	Broadford, Hurdlestown	4·51
,,	Scarborough, Scalby	3·42	XXI.	Enniscorthy, Ballyhyland	5·20
,,	Ingleby Greenhow	2·44	,,	Rothnen, Clonmannon	4·75
,,	Mickleton	3·90	,,	Ballycumber, Moorock Lodge	...
X.	Bellingham, High Green Manor	3·77	,,	Balbriggan, Ardgillan	6·26
,,	Ilderton, Lilburn Cottage	3·36	,,	Castle Forbes Gardens	5·02
,,	Thirlmere, The Bank	3·54	XXII.	Ballynahinch Castle	4·92
XI.	Llanfrechfa Grange	4·24	,,	Woodlawn	4·26
,,	Treherbert, Tyn-y-waun	4·47	,,	Westport, St. Helens	3·50
,,	Carmarthen, The Friary	3·14	,,	Dugort, Slievemore Hotel	3·68
,,	Fishguard, Goodwick Station.	2·64	XXIII.	Enniskillen, Portora	5·37
,,	Crickhowell, Tal-y-maes	5·00	,,	Dartrey [Cootehill]	4·63
,,	New Radnor, Ednol	3·57	,,	Warrenpoint, Manor House	6·18
,,	Birmingham WW., Tyrmynydd	4·54	,,	Belfast, Cave Hill Road	5·36
,,	Lake Vyrnwy	4·89	,,	Glenarme Castle	5·33
,,	Llangynhafal, Plâs Drâw	3·36	,,	Londonderry, Creggan Res.	6·05
,,	Dolgelly, Bryntirion	4·43	,,	Dunfanaghy, Horn Head	6·66
,,	Bettws-y-Coed, Tyn-y-bryn	3·70	,,	Killybegs	6·33

THAMES VALLEY RAINFALL. ——— MAY, 1916.

Symons's Meteorological Magazine

Watershed of River Thames above Teddington, and River Lee above Feildes Weir.

Rainfall Stations reporting.

Isohyetals.

THE WEATHER OF MAY.

DURING the first seventeen days of the month cold, rainy, and sunless weather prevailed, but in the last fortnight these conditions were reversed in most parts of the United Kingdom. The mean temperature of the whole month was slightly under the average in Scotland and Ireland but above the average in England, Wales and the Channel Islands, where there was a general excess of about 2° F., ranging from 3° in the English Channel and the east of England to about a degree in the north-west. During the greater part of the month there was a pronounced tendency for high barometric pressure in the north and low pressure in the south, and in many cases shallow depressions were located over the North Sea. During the first ten days shade frosts were common in Scotland, the north of England and Wales, and in Ireland, the minimum temperature falling to 28° at Cally Gatehouse, on the 10th, and to 29° at several other Scottish stations on the 4th. At Balmoral as late as the 14th a minimum of 28° was recorded. On the other hand temperature did not fall during the month below 40° at the English Channel stations.

About the 17th a period of fine warm weather set in which culminated on the 21st when the temperature rose to 85° at Camden Square, and to 83° at Norwich and Raunds. At Camden Square the above high value has been exceeded only in four Mays back to 1858, while the mean shade maxima from the 18th to the 21st was 81°·2. The last ten days were relatively cool in Scotland, while in Ireland temperature was again below the normal. On the 31st Balmoral reported a shade minimum of 30°.

In Scotland sunshine was deficient throughout the month, but over England and Ireland the last fortnight was sunny. The average daily deficit over the whole country was about an hour, and ranged from two hours in the south-west of England, including the Channel, to half-an-hour per diem in Ireland and the south-east of England.

The durations at individual stations were as follows:—Totland Bay, 212 hours; Sidmouth, 199 hours; Copdock, 191 hours; Southport, 190 hours; Haverfordwest, 170 hours: Loch More, 161 hours; Paisley, 156 hours; Camden Square, 156 hours; Hodsock Priory, 151 hours; Swinton, 146 hours; Perth, 141 hours; Bolton, 127 hours; Hull, 103 hours.

Rainfall was in excess of the average nearly everywhere, except over the extreme south of England, and at a few places in the Midlands. As in April there was a pronounced deficit at coastal stations in the south, including the Devon-Cornwall Peninsula. There was a marked excess in the north-east of Ireland, where more than double the normal fell. The greatest rainfall, ten inches or more, fell in isolated patches in Carnarvon and Connemara, and the least, slightly under 1½ in., in narrow strips to the north and east of the Isle of Wight, the former extending to the vicinity of Andover and the latter to Bognor. A heavy rain occurred on the last day of the month over the north of Ireland, and the west of England and Scotland. The amounts in general were under two inches, but at Seathwaite as much as 4·50 in. fell. Over nearly the whole of England and Wales, except the normally rainy localities, falls of an inch were rare. On the 5th a depression over the Bay of Biscay travelling north gave falls approaching to two inches in the south of Ireland, and on the 24th and 31st thunderstorms in some southern and western localities caused heavy precipitation

In the Thames Valley the rainfall showed variations from an inch-and-a-half at the mouth of the Thames, and in patches round Wallingford and Horsebridge, to three inches on the Cotteswolds and North Downs around Caterham.

The general rainfall expressed as a percentage of the average was:—England and Wales, 120 per cent.; Scotland, 147 per cent.; Ireland, 174 per cent; British Isles, 141 per cent. In London (Camden Square) the mean temperature was 57°·2, or 3°·2 above the average. Duration of rainfall, 34·7 hours. Evaporation, 2·32 in.

Climatological Table for the British Empire, December, 1915.

STATIONS. (*Those in italics are South of the Equator.*)	Absolute. Maximum. Temp.	Date.	Absolute. Minimum. Temp.	Date.	Average. Max.	Min.	Dew Point.	Humidity.	Absolute. Max. in Sun.	Min. on Grass.	Total Rain Depth.	Days.	Aver. Cloud.
	°		°		°	°	°	0-100	°	°	inches		
London, Camden Square	56·8	10	27·6	13	48·7	38·9	40·8	88	78·8	25·0	5·64	22	6·3
Malta	70·7	9	48·3	15	64·4	55·7	...	92	109·0	...	·75	4	2·2
Lagos	92·0	22, 24	71·0	9	88·9	74·8	73·5	74	149·0	69·0	·00	0	4·5
Cape Town	96·7	29	52·5	17	79·0	59·9	55·6	62	...	...	·51	7	3·8
Johannesburg	81·8	19	47·1	8	75·2	53·8	54·9	78	...	46·9	4·27	9	4·2
Mauritius	90·4	10	67·6	24	86·0	71·8	67·2	70	...	59·9	2·16	18	6·1
Bloemfontein	92·3	27	48·3	5	84·0	57·8	50·5	50	..	...	3·48	8	3·9
Calcutta	81·9	4	52·3	20	77·7	56·5	54·9	68	...	40·1	·00	0	1·2
Bombay	87·9	1	67·3	7	83·9	70·6	65·4	69	135·2	50·4	·07	1	1·1
Madras	86·5	16	63·8	5	84.4	69·9	65·9	74	153·3	60·5	·41	4	3·6
Colombo, Ceylon ...	91·7	19	66·4	7	85·8	71·5	69·5	78	163·0	59·8	1·49	6	4·3
Hongkong	80·1	8	49·5	19	67·9	58·6	50·8	62	...	...	·78	3	3·9
Sydney	88·0	2	53·4	22	72·6	61·6	58·3	69	142·8	47·0	3·04	16	7·0
Melbourne	101·0	28	46·2	8	73·5	54·0	49·3	58	153·8	38·1	·55	6	5·4
Adelaide	103·2	27	48·3	6	84·6	58·1	50·0	43	159·0	39·8	·06	2	2·7
Perth	104·6	25	55·3	1	86·6	63·7	53·6	48	168·7	48·0	·14	3	1·8
Coolgardie	103·8	26	48·4	1	92·4	60·1	48·0	32	155·4	...	·08	2	2·1
Hobart, Tasmania ..	85·7	28	43·5	27	68·6	50·4	45·7	58	146·2	32·0	·21	6	6·2
Wellington	77·6	27	45·6	2	67·2	55·8	52·9	74	147·0	33·6	1·21	8	7·7
Auckland	77·0	19	48·5	3	70·1	56·8	56·3	77	158·0	45·0	·54	5	5·2
Jamaica, Kingston ..	88·1	30	68·1	2	85·7	70·4	69·8	79	...	...	·56	2	...
Grenada	88·0	10	71·0	15	85·0	74·0	...	75	136·0	...	5·93	23	2·0
Toronto	40·6	17	9·8	31	33·0	22·2	23·2	86	98·5	2·6	2·52	13	7·5
Fredericton	49·0	26	1·0	16	31·4	19·1	21·5	86	...	...	3·88	12	7·0
St. John, N.B. ...	50·2	26	8·0	31	33·7	23·2	24·7	77	...	2·8	4·96	16	6·8
Alberta, Edmonton ...	41·0	3	—3·9	13	26·8	11·0	...	83	83·0	—8·8	·31	9	6·1
Victoria, B.C.	51·3	20	27·0	30	45·1	37·8	37·0	84	102·0	18·0	4·78	21	7·4

Johannesburg.—Bright sunshine, 287·3 hours.

Mauritius.—Mean temp. 0°·4 above, dew point 0°·7 below, and R 2·70 in. below, averages. Mean hourly velocity of wind, 11·9 miles.

COLOMBO, CEYLON.—Mean temp. 78°·7, or 0°·4 below, dew point 2°·0 below, and R 3·08 in. below, averages. TS on 2 days. Distant T and L on 10 days.

HONGKONG.—Mean temp. 63°·4, mean hourly velocity of wind 10·5 miles. Bright sunshine 214·5 hours.

Melbourne.—Mean temp. 0°·8 below and R 1·76 in. below, averages.

Adelaide.—Mean temp. 0°·2 above and R ·90 in. below, averages.

Perth.—Mean temp. 4°·6 above normal, and the hottest Christmas Day on record.

Coolgardie.—Temp. 0°·1 above and R about half-an-inch below, averages.

Hobart.—Mean temp. 0°·8 below, and R 1·72 in. below, averages.

Wellington.—Mean temp. 1°·1 above and R 2·12 in. below, averages. Bright sunshine 218·3 hours; Bright and sunny month.

Auckland.—Mean temp. and sunshine slightly above average, and R more than 2 in. below average.

ALBERTA, EDMONTON.—A warm, dry month. Frost in air and on S every night. Fog on 5 days.