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THE THEORY OF HALOS AND PARHELIA.

[It has long appeared to us that a thoroughly accurate and yet clear explanation of the formation of Solar and Lunar Halos, and of Mock Suns and Mock Moons (known also as Parhelia and Paraselene), was needed, and we are much indebted to the Rev. A. K. Cherrill for preparing the paper, which will be completed in our June number. —ED. *M.M.*]

CORRECTION OF A PREVALENT ERROR.

COLOURED rings of small diameter are often seen surrounding the Moon. The innermost circle is generally quite close to the Moon; but the size of the rings is variable, and when they are larger than usual observers have sometimes mistaken them for halos. As it is important that this should be avoided, it will be well to say a few words about these small coloured rings, or coronæ as they are called, and to point out how they differ from the true halos. Coronæ as often surround the Sun as the Moon, though they are then more difficult to discern, being obscured by the brightness of his rays. They are best seen when the reflection of the Sun is observed in still water. These rings were observed and measured by Sir Isaac Newton. A set of two about the Moon had diameters of three and of five and a half degrees, the colours being blue next the Moon and red without. A larger set of three surrounding the Sun had diameters of five, nine, and twelve degrees, the colours being in the same order. Newton explained these rings by the light passing through very minute drops of water, the colours being produced by interference. He found by calculation that if the drops were 1-500th of an inch in diameter, the diameters of the rings would be about seven, ten, and twelve degrees, the rings being larger when the globules are small, and smaller when the globules are larger. These coronæ, then, differ from the true halos in their small and variable size, in the order of the colours, (the halos having the red next the Sun) in never being accompanied by parhelia or paraselene. The cause by which they are produced is also different. Coronæ are the result of thin watery mists in the lower strata of the atmosphere, while the true halos are attributed to ice crystals floating in the upper regions.

THE ORDINARY HALO.

A good example of the true halo, which is less common than the coronæ, occurred in the neighbourhood of London on January 29th, 1890, and was described with an illustrative sketch in the *Meteorological Magazine*, vol. xxv., p. 2. The general appearance of a halo of this description is represented in Fig. 1, where H H is the horizon, Z the zenith, and S the position of the Sun. The circle B A C, having the Sun for its centre, is called the halo of 22 degrees, its semi-diameter being an arc of 22 degrees of a great circle of the heavens. It shews prismatic colours, the red being inside, or nearest the Sun, and the violet outside; but the intermediate colours are generally faint, and sometimes disappear altogether, so that the appearance of two separate bands may be presented.*

A similar but larger circle, G E D F K, is known as the halo of 46 degrees, that being its distance from the Sun.

G B S C K is a band of white light passing through the Sun, and is named theparhelic circle. E A F and L D M are prismatic arcs, the upper one having the zenith for its centre, and touching the highest point of the two circles surrounding the Sun.† The colours of these arcs are brighter than those of the circles, and are in the same order reckoning from the Sun, but in the reverse order if we reckon from the centres of the circles. That is to say, the red is always nearest the Sun, and so circles surrounding the Sun have the red on their inner side as in the secondary rainbow, while circles convex to the Sun have the red on their outer side, as in the primary bow.

PARHELIA, OR MOCK SUNS.

Mock suns are usually seen at or near the points B and C, where the white band crosses the inner circle, and they may also be seen at the crossing of the outer circle, and at some other points in the parhelic circle.

SUN PILLAR.

There is also sometimes seen a vertical band of white light in the direction D A S, which may be prolonged below the Sun. This is not represented in the figure. It is called in the Orkneys a "Sun pillar," and is rarely visible except after sunset, or before sunrise,

In comparing this general description with particular examples of halos, it must be remembered that just as the rainbow is sometimes

* This is probably the appearance described by a correspondent (*Met. Mag.* vol. xx., p. 89), though the distance between the bands not being given, renders it somewhat uncertain.

† Tangent arcs may also occur at other points, but these will not have the zenith for their centre.

seen complete down to the ground, while sometimes only one or two small fragments of it appear, so the circles and arcs of the halo may vary very greatly in completeness, and also in brightness, and some of them may be wholly absent. Another case of variation in appearance is that in the circle turned away from the Sun having the zenith for its centre, the curvature will differ according to the height of the Sun above the horizon. Moreover, when only a small arc of this circle is seen, as is usually the case, it is not easy for the eye to determine its centre; and thus in sketches which are not very carefully made, the arc may be erroneously represented as having some other point than the zenith as its centre. The curvature of the tangent arcs to the halo of 22° also varies with the elevation of the Sun, and in some cases is reversed, so as to form an eclipsed halo surrounding the Sun.

When the white band passing through the Sun is short its curvature will hardly be perceived; and if there is also a perpendicular white band, the appearance of a cross will be presented. On the other hand the horizontal white band, which is parallel to the horizon, and therefore has the zenith for its centre, may be prolonged into a complete circle, and so be seen in the part of the sky opposite the sun; or the part of it opposite the Sun alone may be visible, thus presenting the appearance described and figured as a zenithal halo in *Met. Mag.*, vol. xvi., p. 92; or, again, a small portion of it may be seen at a considerable distance from the Sun. Such may have been the "brilliant patch of pure white light in the north western sky, at a distance of 90° from the western mock sun," which is described as forming one of the most noteworthy features of the halo of January 29th, 1890. Another source of variation is that the tangential arcs, though usually seen touching the highest points of the circumsolar circles, may occur at other points also. A curious halo is figured in *Met. Mag.*, vol. xiii., p. 45. This is a good example of the way in which the appearance may differ from the ordinary type. It may be described as a halo in which only the inner circumsolar circle and two tangent arcs to the outer circle are visible. It is true that the distance between the inner circle and the arcs is rather too small in comparison with the diameter of the circle for this explanation; but as the halo lasted only a short time, and was apparently sketched from memory, this is easily accounted for.

The Theory of Halos.

Let us pass now to the theoretical explanation of these halos. Sir Isaac Newton believed them to be produced by a different cause from the coronæ previously mentioned. He attributed them to "some sort of hail or snow floating in the air in a horizontal position, the refracting angle being about 58 or 60 degrees." Huygens also thought that these appearances were due to floating crystals of ice; but he rendered his theory more complicated by assuming the existence of cylindrical particles of hail having opaque nuclei. The formation of these cylinders he explained in the following manner:—He supposed particles of snow first to adhere together in a globular form, and to be supported by an ascending current of air. Other particles would then be frozen on to the top or bottom of the mass, the sides being kept clear by the current of air, and a cylindrical form would be thus obtained. Afterwards he supposed these cylinders to be partially thawed, and then again frozen, so as to become transparent ice on the outside, while remaining opaque internally. By means of these supposed cylinders Huygens was able to explain in detail the principal phenomena of halos; but it must be admitted that the account of their formation is too complicated to be at all probable. Fortunately, however, subsequent research has shewn them to be quite unnecessary, and the phenomena have all been satisfactorily accounted for by a return to the simpler hypothesis of Newton.

Dr. Young found that the inner circle of 44 degrees in diameter could be formed by crystals of ice floating in the air, and having refracting angles of 60°. To explain the outer circle 92 degrees in diameter, he supposed that rays which have been refracted by one ice crystal might again fall upon, and be refracted by, a second crystal. This, however, does not appear likely, and a more satisfactory suggestion was made by Cavendish, who supposed the ice crystals to have flat ends forming angles of 90 degrees with their sides, in which case refraction through these rectangular ends would completely account for the outer circle.

This suggestion of Cavendish may be said to complete the main part of the theory of halos; but the subject was further worked out in detail by M. Bravais, a French naval officer, who produced, in the year 1847, an elaborate "Mémoire sur les Halos," which still holds its place as the best exposition of the subject.

The explanation of parhelia and halos thus finally arrived at is optically simple, at least as far as the more ordinary phenomena are concerned; the chief difficulty in understanding it arises from the complicated perspective which it involves.

Suppose an observer to stand facing the Sun. A ray of light, S A, Fig. 2, which, if not intercepted, would have passed over the observer's head, falling upon an ice crystal in a suitable position at A, would be bent downwards to meet the eye, and thus produce an image of the Sun seen in the direction of the crystal, and therefore above the Sun's real position. Another ray, S_2 B, which would have passed still higher over head, would also be brought down to the eye if refracted by the angle of 90° of another crystal at B, and thus produce a second image of the Sun above the first. It is evident, however, that this would take place not only in the vertical plane, but also in all planes passing through the eye and the Sun, provided that crystals presented themselves in the proper position.

If we imagine the plane of Fig. 2 to revolve about the line E S as an axis, the lines E H_1, E H_2, will trace out two cones, having the eye for their common vertex, and the two circles of the halo for their bases, and any crystal on the surface of these cones will be similarly situated with regard to the eye and the Sun to the two crystals shewn in the figure. In the corresponding explanation of the rainbow this is all that we have to consider. The drops of water being spherical, it is enough if they are in the proper situation, all positions of the drop are the same. But it is otherwise with regard to the crystals we are now considering. They must not only be in the right situation, but also in the right position. Thus the prisms which produce the halo of 22° must have their axes perpendicular to the plane of the figure, that is the plane in which the Sun, the eye, and the crystal are situated; while the crystals producing the halo of 46° must have their axes lying in this plane. The importance of this observation will be apparent when we come to consider the explanation of the parhelia. Crystals thus placed, and being also rotated about their axes into the position producing minimum deviation, will form a series of images of the Sun all at the same distance, and these, by their coalescence, will produce the two circles of the halo. To test the truth of this explanation we must consider how it will account for the constant size of the rings. We will suppose the crystals to be in the position which produces the minimum amount of deviation, which takes place when the ray enters, and emerges at an equal distance from the vertex, and therefore, in the case of an isosceles prism, passes through in a direction parallel with the base. The deviation on leaving the crystal is thus equal to that on entering it, or the total deviation is double that caused by the light entering the crystal. Let C A D be the normal to the surface at the point A. Thus, S_1 A C is the angle of incidence, D A F the angle of refraction, and since A F is parallel to the base of the equilateral prism, D A F must equal 30°. Now the index of refraction of ice being 1·31, we know by the law of refraction that Sin S_1 A C = 1·31 Sin D A F; but Sin 30° = $\frac{1}{2}$, therefore Sin S_1 A C = $\frac{1}{2}$ of 1·31 = ·655, and this will be found by the tables to be the sine of 40° 56′, which is therefore the angle of incidence, and the angle of refraction being, as already stated, 30°, the deviation at the first surface will be 10° 56′, and the total deviation, that is the angle S E F, equals 21° 52′, which gives 43° 44′ as the diameter of the inner circle.

The calculation for the outer circle may be given more briefly as follows :—

Refracting angle	90°
Angle of refraction for minimum deviation...	45°
Sine 45°	= ·7071
Sine of angle of incidence = ·7071 × 1·31	= ·9263
Angle of incidence	= 67° 52′
Deviation at first surface	= 22° 52′
Total deviation	= 45° 44′
Diameter of circle	= 91° 28′

These results, correspond so closely with the observed dimensions of the rings, as to afford a strong confirmation of the theory.

It remains, however, to account for the circular arcs turned away from the Sun, which touch the upper portions of the two rings. Hitherto we have confined our attention to refractions which take place in planes passing through the eye and the Sun. To account for this part of the phenomena we must consider the effect of refractions not wholly in one plane.

It is here that the difficulties of perspective already referred to come in. In the case of the two circles round the Sun, the perspective is exactly the same as in the rainbow, and needs no special explanation. To understand the present more difficult case, let us first alter our point of view. In Fig. 2 the observer is at E and the Sun at S, and in looking at the diagram we face in a direction at right angles to the line E S. In looking at Fig. 3, on the other hand, we are supposed to face in the same direction as the observer at E, and thus to see the line S E foreshortened. S B K E in Fig. 3 is the same line as S_2 B K E in Fig. 2; but, of course, the bendings of the line at B and K cannot in this case be represented. The crystal at B, Fig. 3, has its axis vertical, and one of its sides exactly facing the observer. A ray of light falling on the flat upper end of this crystal will be bent downwards in the way already explained, but it will not be deflected either to the right or left, and will form the upper part of the larger circle. Next suppose another prism at C somewhat to the left of the first, and also with its axis vertical. If the front surface of this prism should be parallel to that of the first, it is clear that the ray refracted by it would pass to the left of the observer and be unperceived by him. But if the face of the crystal should be turned a little away from the observer, then the ray on striking its second surface would be inclined to a vertical plane perpendicular to the face of the crystal, and therefore, according to the laws of refraction, on emerging from the crystal it would be bent not only downwards, but also further away from that plane and towards the eye of the observer. Thus an image would be seen to the left of the former, but at the same apparent elevation, for the deflection in the vertical plane would be the same in each case, and by the coalescence of a number of such images a horizontal band would be produced touching the top of the outer circle. The tangent to the inner circle may be explained in a similar manner, by refraction though the angles of 60°, the axes of the crystal being in this case horizontal.

A question of some interest arises here. Do the tangent circles overlap or coincide with the circumsolar circles at the point of contact, as shewn in Fig. 1? Or are they distinct throughout, touching only at their outer edges, as represented in the figure of the halo of Jan. 29th, 1890, *Met. Mag.*, vol. xxv., p. 2? The circumsolar circles are regarded as being formed by crystals so placed as to give minimum deviation, the upper tangent circle by crystals having their axes vertical. Now, on referring to Fig. 2, it will be seen that when the crystal at B is so placed as to produce minimum deviation (as there represented), the angle between the line E K and the normal at the point K is equal to the angle of incidence = 67° 52′, and the angle between E K and the horizontal line E L is equal to K E S + S E L = 45° 44′ + the Sun's elevation. Consequently, if the Sun's elevation is 22° 8′, the normal at K and the horizontal line will make equal angles with E K, and will therefore be parallel to each other; or, in other words, the crystal at B in the position of minimum deviation will have its axis vertical, and therefore, in this case, the circles will coincide or overlap where they meet, as shewn in Fig. 1. If, however, the elevation of the Sun is either greater or less than 22 degrees, the vertical crystal will not be in the position of minimum deviation, and will therefore produce a greater deviation, and the tangent circle will be more or less outside the circumsolar halo.

It must be remembered, however, that when a prism is turned out of the position of minimum deviation, the displacement of the image is at first very slight, and therefore for some degrees on both sides of the elevation of 22° the two circles would overlap to a considerable extent.

(To be continued.)

ROYAL METEOROLOGICAL SOCIETY.

THE usual monthly meeting of this Society was held on Wednesday evening, March 18th, at the Institution of Civil Engineers, 25, Great George-street, Westminster, Dr. C. Theodore Williams, vice-president, in the chair.

Mr. H. Brevitt, Mr. J. Lovel, and Mr. L. G. Oliver, were elected Fellows of the Society.

Mr. G. J. Symons, F.R.S., read a paper entitled "A Contribution to the History of Rain Gauges." It appears that Sir Christopher Wren, in 1663, designed not only the first rain gauge, but also the first recording gauge, although the instrument was not constructed till 1670. The earliest known records of rainfall were made in the following countries:—France, Paris, 1668; England, Townley, in Lancashire, 1677; Switzerland, Zurich, 1708; and Ireland, Londonderry, 1711. Mr. Symons gave a very full account of the various patterns of rain gauges, and in most instances pointed out the merits or defects of each.

Mr. A. W. Clayden, M.A., showed on the screen a number of interesting photographs of clouds, lightning flashes, and other meteorological phenomena.

The meeting was adjourned at 8.30 p.m., in order to allow the Fellows to inspect the Exhibition of Rain Gauges, Evaporation Gauges, and new instruments, which had been arranged in the rooms of the Institution.

Almost every known pattern of rain gauge that has been at all generally used in this country was shown, and it was interesting to compare the old patterns with the new ones. Most of the gauges had funnels 5 or 8 inches in diameter. The Meteorological Office 8 inch gauge is by some regarded as the best gauge for ordinary observers to whom cost is not a primary object, as it has all the good features of the Glaisher and of the Snowdon patterns, and, being of copper, is very durable. In mountainous districts, where the rainfall is heavy, and the gauges can be examined only periodically, gauges capable of holding 40 or 50 inches of rain must be used. Specimens of these gauges, as well as of the rain and snow gauges used in France, Germany, Russia, Switzerland, and the United States, were shown. Some interesting storm gauges and self-recording gauges were also exhibited. The evaporation gauges included several instruments employed for measuring the evaporation from a free surface of water, and others for use with growing plants. Many new instruments were also exhibited, among which were various anemometers, and cameras for meteorological photography. Maps of rainfall over the British Isles and over various parts of the world, as well as numerous photographs of floods, meteorological phenomena, &c., were also on view.

The usual monthly meeting was held on Wednesday, April 15th, at the Institution of Civil Engineers, 25, Great George-street, Westminster; Mr. A. Brewin, Vice-President, in the chair.

Mr. J. Baxendell, Mr. H. Champ, and Mr. S. H. Ridge, B.A., F.R.G.S., were elected Fellows of the Society.

The following papers were read :—

(1.) "Some remarkable features in the winter of 1890-91," by Mr. F. J. Brodie, F.R.Met.Soc. The author points out the peculiarities in the weather which prevailed over the British Isles during the past winter. In addition to the prolonged frost which lasted from the close of November to about January 22nd, he finds that the barometric pressure for the whole winter was about a quarter of an inch above the average; and that when the wind was not absolutely calm, there was an undue prevalence of breezes from some cold quarter. The percentage of wind from the southward did not amount to one half of the average. The number of foggy days in London was twice the average. The rainfall over the greater part of the British Isles was less than half the average. The author says that almost every element in the weather has been influenced to an abnormal degree by the remarkable prevalence of high barometrical pressure, the winter of 1890-91, may therefore be defined as the "anti-cyclonic winter."

(2.) "The Rainfall of February, 1891," by Mr. H. Sowerby Wallis, F. R. Met. Soc. This was an elaborate report of one of the driest months upon record; the mean rainfall over England, excluding the Lake District, being only ·066in., or about one-fortieth of the average. The paper was of course, chiefly tabular, but the facts were epitomized by a map, showing the relative intensity of the phenomemon in various parts of the British Isles.

(3.) "On the variations of the rainfall at Cherra Poonjee, in the Khasi Hills, Assam," by Mr. H. F. Blanford, F.R.S. Cherra Poonjee (Lat. 25° 17′ N., Lon. 91° 44′ E.) has long been notorious as having a heavier rainfall than any other known place on the globe; the mean annual fall being frequently given as about 600 inches. Mr. Blanford has made a critical examination of the various records of rainfall kept at this place, and has come to the conclusion that the above amount is too high, but that the average annual rainfall is probably a little over 500 inches.

REVIEWS.

Bulletin Annuel de la Commission de Météorologie du Département des Bouches-du-Rhone. Année 1889, 8*me année.* Marseilles: Barlatier et Barthelet, 1890. 4to, 108 pp., map and diagrams.

THE department of Bouches du Rhone is one of those in which Le Verrier's idea of Departmental Meteorology is at last well carried out—we say at last, because, as will be seen above, the present series of bulletins dates back to 1881 only—now, however, all seems well organized. The area of the department is about as much larger than the county of Surrey, as it is smaller than that of Essex. The Commission have in it thirty-six stations, of which five are at lighthouses or ports on the Mediterranean and the rest are well distributed inland.

The barometric values are generally very accordant, but two—Port de Bouc and Planier—are wrong, the former about $5^{mm.}$ too high, the latter about $4^{mm.}$ too low. This station of Planier—at the lighthouse on the Isle de Planier, a few miles outside of the harbour of Marseilles—seems to us to need the supervision of the Commission. Lighthouses, as we all know, are rarely in situations suitable for rain gauges, and this volume does not state the height of the rain gauges above the soil, but with rainfall totals at the other coast stations all ranging between 24 and 28 inches, we cannot accept 15 inches at La Ciotat, or still less 12·44 inches at Planier. As regards the inland stations, the records generally seem very good, but those for Meyrargues are incomprehensible; surely they are the records for another year?

The volume contains a very clear map of the Department, with the stations plainly marked. Our French friends are so skilled at map work that we believe they could, without sacrificing the clearness of the map, indicate by light shading the orography of the Department; by so doing they would confer a further benefit on the readers of their volumes.

We are sorry to see that the Commission have not yet given up the old plan of beginning the year with December. They will have to make the change eventually, and the sooner they fall in with the practice of the greater part of Europe, the better for everybody.

We must not omit to notice two important Memoirs which are given in the Appendix—one by M. Stephan, Director of Marseilles Observatory, on the climate of that city, with a diagram showing on the average of the twenty years 1867—86, the mean, and the mean max. and mean min. temperature of every day in the year; and a paper by Dr. Mireur on the relation of climate to disease, illustrated by a series of inexpensive but very effective diagrams.

Meteorological Observations made at the Adelaide Observatory and other places in South Australia and the Northern Territory, during 1883 *and* 1888, *under the direction of* C. TODD, C.M.G., F.R.S. 2 vols. Fcap. folio. Adelaide, 1889, 1890.

WE are very glad to find that the South Australian Government has enabled Mr. Todd to resume the publication of his useful volumes, and trust that it will not be long before he is able to give us the years 1884—1887, for which we are still waiting.

Mr. Todd has done, and is doing, excellent work in South Australia, and his volumes are such as need not fear comparison with those of any observatory in the old country. For instance, Greenwich has recently advanced so far as to give us the readings *in extenso* of thermometers on a Stevenson screen in addition to those on the Greenwich stand; but this Adelaide volume gives us four sets :—(1) the old Adelaide stand, (2) a Greenwich stand, (3) a Stevenson, (4) a *thermomètre fronde.* And it not merely gives the records and an analysis of them, but it gives as a frontispiece to the volume a view of the grounds showing the stands *in situ.* We should expect an earthquake at least if Greenwich condescended to give a picture.

Still even Adelaide might, we think, do better in one or two little points. In the 1883 volume Mr. Todd says that at the observatory they had three rain gauges, two at 1ft. above ground and one at 2ft., but "*the adopted rainfall during the day,* given in the monthly tables, *is the greatest quantity collected in any one of the three gauges.*" Why? We fail to see any reason for this. Suppose instead of three gauges he had thirty, would he still pick out the highest reading? If so, then the magnitude of the record is merely dependent on the number of rain gauges which one has. We have heard persons contend that a rain gauge cannot catch too much, and so try to justify their practice of doing as Mr. Todd has done. We have no doubt that upon consideration Mr. Todd will agree with us that the British plan of keeping the record of each gauge separately is by far the best.

We are very glad to see that a Beckley Recording Rain Gauge has lately been added to the instruments at the observatory, and we hope that funds will allow a few of the important curves each year being reproduced in the annual volumes.

THE COLDEST MONTH.

To the Editor of the Meteorological Magazine.

SIR,—Having seen Mr. King's statement of the mean temperatures of all the Januaries and Decembers from 1872 to 1890 inclusive, at Elswick Lodge, Garstang, Lancashire, I take the liberty of sending you a similar statement for the same period, of the temperatures here, from which you will observe that at no period since the end of 1880, has the average temperature of all the previous Januaries equalled those of the Decembers, but as the difference at the end of the 19 years is only 0°·01, it would take a longer period than 19 years of comparison to ascertain which is the coldest month. By making a similar statement beginning with Dec. 1872 and Jan. 1873, and ending with Dec. 1890 and Jan 1891, the result would be that the Januaries are colder than the Decembers by an average of 0°·38, instead of only 0°·01. This statement includes Dec. 1890, the coldest of the Decembers, but does not include Jan. 1891, 34°·45, 7°·05 colder than Jan. 1872.

Yours truly,
CLEMENT H. GOSSET.

Langton Herring, Weymouth, April 22nd, 1891.

Comparison of the Mean Temperatures of all the Januaries and Decembers from 1872 *to* 1890, *inclusive, at Langton Herring, Weymouth.*

	JANUARY. Mean of each Year.	JANUARY. Average Mean.	DECEMBER. Mean of each Year.	DECEMBER. Average Mean.	Average Mean of January as compared to that of December.
1872	41·50	41·50	43·70	43·70	— 2·20
3	42·38	41·95	42·60	43·15	— 1·20
4	43·35	42·43	34·60	40·30	+ 2·13
5	44·14	42·85	38·80	39·92	+ 2·93
6	37·77	41·84	44·26	40·80	+ 1·04
7	44·26	42·25	40·90	40·82	+ 1·43
8	41·00	42·07	33·45	39·77	+ 2·30
9	32·77	40·91	33·36	38·97	+ 1·94
1880	33·61	40·01	44·48	39·59	+ ·42
1	29·90	39·08	41·54	39·78	— ·70
2	41·45	39·29	41·26	39·92	— ·63
3	41·64	39·48	40·90	40·00	— ·52
4	44·00	39·98	41·19	40·09	— ·11
5	37·68	39·68	39·39	40·04	— ·36
6	36·80	39·49	38·02	39·90	— ·41
7	36·97	39·33	38·32	39·81	— ·58
8	37·86	39·24	42·55	39·96	— ·72
9	38·35	39·19	38·97	39·91	— ·72
1890	43·58	39·42	30·97	39 43	— ·01

CLIMATOLOGICAL TABLE FOR THE BRITISH EMPIRE, OCT., 1890.

STATIONS.	Absolute.				Average.				Absolute.		Total Rain.		Aver.
	Maximum.		Minimum.										
(*Those in italics are South of the Equator.*)	Temp.	Date.	Temp.	Date.	Max.	Min.	Dew Point.	Humidity.	Max. in Sun.	Min. on Grass.	Depth.	Days.	Cloud.
	°		°		°	°	°	0-100	°	°	inches		
England, London	68·5	4	23·8	28	57·9	42·4	43·3	80	109·4	16·8	1·20	13	5·3
Malta	83·2	8	52·6	31	74·8	61·8	58·8	80	141·2	46·0	5·31	11	3·8
Cape of Good Hope	88·2	17	41·8	7	69·5	53·2	...	...	...	...	1·48	...	5·0
Mauritius	79·0	15*a*	54·3	1	76·8	65·6	62·5	77·3	131·5	46·3	1·25	15	6·2
Calcutta	89·7	3	66·9	27	84·6	73·2	74·2	85	153·0	60·5	8·54	11	3·9
Bombay	92·0	30	71·8	31	86·6	75·6	73·2	78	140·8	57·7	·58	3	2·5
Ceylon, Colombo	87·7	25	71·8	26	84·7	75·2	71·5	80	150·0	68·0	13·33	20	7·0
Melbourne	76·0	4, 7	42·6	2	65·5	48·5	45·0	66	130·4	33·0	1·99	19	6·9
Adelaide	83·8	4	41·8	17	68·9	50·3	47·8	65	144·0	33·1	2·54	20	5·0
Wellington	67·3	14	42·0	17	62·6	49·6	46·3	70	125·0	35·0	4·67	14	3·1
Auckland	75·0	11	48·0	21	65·9	52·4	50·5	74	133·0	38·0	10·21	20	6·6
Jamaica, Kingston	92·5	7	70·2	18	88·3	72·5	70·6	73	...	...	2·41	...	...
Trinidad	90·2	4	68·0	12	86·8	70·6	71·7	82	156·0	60·0	10·98	25	...
Toronto	69·9	4	29·0	30	54·7	42·4	43·7	82	...	21·5	4·94	19	7·6
New Brunswick, Fredericton	75·3	2	21·9	23	52·6	34·7	38·0	77	...	...	2·13	13	6·0
Manitoba, Winnipeg	77·5	1	26·0	26*b*	49·5	33·7	37·8	85	...	...	3·68	15	7·4
British Columbia, Esquimalt	59·6	2	35·8	10	53·2	42·5	45·5	91	...	...	5·28	22	7·2

a And 16, 17, 23. *b* And 29.

OCTOBER REMARKS.

MALTA.—Mean temp. 66°·5 ; mean hourly velocity of wind, 8·7 miles ; sea temp. fell from 75°·0 to 70°·5. TSS on 6 days ; L on 10th and 24th; H on 24th. J. SCOLES.

Mauritius.—Mean temp of air, 1°0 below ; dew point 1°·0 above, and rainfall ·61in. below, their respective averages ; mean hourly velocity of wind, 9·2 miles, or 2·4 below average ; extremes 21·9 on 19th and 0·0 on 16th ; prevailing direction, E.S.E. to E. Fine fore and after glows occasionally. C. MELDRUM, F.R.S.

Colombo.—TSS occured on the 18th and 19th ; L alone was seen on the 23rd and 24th. J. C. H. CLARKE, Lieut.-Col., R.E.

Melbourne.—Mean temp. of air 0°·1 ; of dew point 1°·3 ; humidity 4 ; and rainfall ·82 in. below their respective averages. Cloud 0·9 above the average. Prevailing winds N. and N.W., strong on 9 days ; fierce squalls from N.W. on 24th ; T and L on 3 days ; H on 15th ; heavy dew on 1st and 10th. R. L. J. ELLERY, F.R.S.

Adelaide.—R ·74in. above and mean temp. 2°·3 below the average of 33 years. Strong winds on 14 days, and gales on 2 days. C. TODD, F.R.S.

Wellington.—Fine generally, with light showers in the early part of the month ; showery during the middle and end. Prevailing winds, N.W., generally strong ; H on 26th. Mean temp. 2°·5 above the average. R. B. GORE.

Auckland.—An exceedingly wet and stormy month, the rainfall being the heaviest ever recorded for October, and more than three times the average (3·17in.) of 23 years. T. F. CHEESEMAN.

SUPPLEMENTARY TABLE OF RAINFALL, APRIL, 1891.

[For the Counties, Latitudes, and Longitudes of most of these Stations, see *Met. Mag.*, Vol. XIV., pp. 10 & 11.]

Div.	STATION.	Total Rain.	Div.	STATION.	Total Rain.
		in			in.
II.	Dorking, Abinger Hall.	·85	XI.	Builth, Llanwrtyd Wells	3·55
,,	Margate, Birchington...	·29	,,	Rhayader, Nantgwillt..	3·91
,,	Brighton, PrestonvilleRd	·66	,,	Corwen, Rhug	2·99
,,	Hailsham	·59	,,	Carnarvon, Cocksidia ...	2·42
,,	Ryde, Thornbrough	·80	,,	I. of Man, Douglas	2·56
,,	Alton, Ashdell...........	·95	XII.	Stoneykirk, Ardwell Ho.	2·60
III.	Oxford, Magdalen Col...	1·41	,,	New Galloway, Glenlee	1·98
,,	Banbury, Bloxham	·81	,,	Melrose, Abbey Gate ...	·61
,,	Northampton	1·94	XIII.	N. Esk Res. [Penicuick]	1·05
,,	Cambridge, Fulbourne..	1·10	XIV.	Ballantrae, Glendrishaig	3·31
,,	Wisbech, Bank House..	·79	,,	Glasgow, Queen's Park.	·81
IV.	Southend	·42	XV.	Islay, Gruinart School..	1·33
,,	Harlow, Sheering	·70	XVI.	Dollar.....................	1·19
,,	Rendlesham Hall	·91	,,	Balquhidder, Stronvar..	2·91
,,	Diss	·94	,,	Coupar Angus Station..	2·27
,,	Swaffham	1·01	,,	Dunkeld, Inver Braan..	2·26
V.	Salisbury, Alderbury ...	1·03	,,	Dalnaspidal H.R.S. ...	2·44
,,	Warminster	1·15	XVII.	Keith H.R.S.	·87
,,	Bishop's Cannings	1·49	,,	Forres H.R.S.	·21
,,	Ashburton, Holne Vic....	2·82	XVIII.	Fearn, Lower Pitkerrie.	·37
,,	Okehampton, Oaklands.	2·78	,,	Loch Shiel, Glenaladale	2·09
,,	Lynmouth, Glenthorne.	2·07	,,	N. Uist. Loch Maddy ...	·45
,,	Probus, Lamellyn	1·90	,,	Invergarry	1·26
	Launceston, S. Petherwin	...	,,	Aviemore H.R.S.	·80
,,	Wincanton, StowellRec.	·73	,,	Loch Ness, Drumnadrochit	·73
,,	Wells, Westbury........	1·23	XIX.	Lairg H.R.S.	...
VI.	Bristol, Clifton	1·23	,,	Scourie	·61
,,	Ross, the Graig	1·53	,,	Watten H.R.S.	·58
,,	Wem, Clive Vicarage ...	2·50	XX.	Dunmanway, Coolkelure	3·75
,,	Cheadle, The Heath Ho.	2·60	,,	Fermoy, Gas Works ...	1·66
,,	Worcester, Diglis Lock	1·29	,,	Darrynane Abbey.........	3·28
,,	Coventry, Coundon	2·59	,,	Tipperary, Henry Street	1·40
VII.	Ketton Hall [Stamford]	1·11	,,	Limerick, Kilcornan ...	2·22
,,	Grantham, Stainby	1·72	,,	Ennis	2·38
,,	Horncastle, Bucknall ...	1·20	,,	Miltown Malbay.........	1·64
,,	Worksop, HodsockPriory	1·39	XXI.	Gorey, Courtown House	1·89
VIII.	Neston, Hinderton	1·72	,,	Mullingar, Belvedere ...	2·72
,,	Knutsford, Heathside ...	2·16	,,	Athlone, Twyford	3·32
,,	Lancaster, Southfield ...	1·95	,,	Longford, Currygrane...	3·64
,,	Broughton-in-Furness ..	3·37	XXII.	Galway, Queen's Coll...	2·21
IX.	Ripon, Mickley	3·25	,,	Crossmolina, Enniscoe..	2·05
,,	Scarborough, WestBank	1·75	,,	Collooney, Markree Obs.	1·92
,,	EastLayton[Darlington]	4·40	,,	Ballinamore, Lawderdale	3·43
,,	Middleton, Mickleton..	2·51	,,	Lough Sheelin, Arley ..	2·60
X.	Haltwhistle, Unthank..	1·33	XXIII.	Warrenpoint	3·45
,,	Bamburgh	1·08	,,	Seaforde	4·12
,,	Shap, Copy Hill	...	,,	Belfast, New Barnsley..	2·79
XI.	Llanfrechfa Grange	2·49	,,	Bushmills, Dundarave...	·82
,,	Llandovery	3·04	,,	Stewartstown	3·16
,,	Castle Malgwyn	2·18	,,	Buncrana	2·04

APRIL, 1891.

Div.		STATIONS. [The Roman numerals denote the division of the Annual Tables to which each station belongs.]	RAINFALL. Total Fall.	Difference from average 1880-9.	Greatest Fall in 24 hours. Dpth	Date	Days on which ·01 or more fell.	TEMPERATURE. Max. Deg.	Date	Min. Deg.	Date	No. of Nights below 32°. In shade.	On grass.
			inches.	inches.	in.								
I.	ENGLAND.	London (Camden Square) ...	1·13	— ·61	·46	4	9	66·3	28	28·1	1	3	1
II.		Maidstone (Hunton Court)...	·53	— 1·12	·25	4	4	...	...	...	...	...	...
,,		Strathfield Turgiss	1·09	— ·51	·35	4	12	66·6	28	25·5	1	8	18
III.		Hitchin	·84	— ·95	·27	4	11	63·0	30	25·0	26	8	...
,,		Winslow (Addington)	1·28	— ·64	·88	4	13	64·0	28	22·0	1	9	19
IV.		Bury St. Edmunds (Westley)	·64	— 1·02	·15	4	12	...	...	...	...	...	...
,,		Norwich (Cossey)	1·06	— ·65	·30	4	15	60·0	29	23·0	1, 19	1	12
V.		Weymouth (Langton Herring)	·72	— 1·16	·21	2	10	59·0	27	31·0	1, 8	2	...
,,		Barnstaple	1·50	— ·68	·37	4	11	67·0	6	30·0	25	...	...
,,		Bodmin (Fore Street)	2·69	— ·38	·42	4	12	...	...	...	...	...	...
VI.		Stroud (Upfield)	1·30	— ·85	·25	4	13	65·0	29	32·0	7, 11	2	...
,,		Church Stretton (Woolstaston)	2·45	+ ·11	·50	21	16	62·0	30	28·5	1	6	14
,,		Tenbury (Orleton)	2·00	— ·08	·42	21	14	65·6	30	24·0	1	7	12
VII.		Leicester (Barkby)	2·07	— ·03	·70	4	13	67·0	30	22·0	26	12	20
,,		Boston	1·11	— ·60	·50	5	11	65·0	26	27·0	18	10	...
,,		Hesley Hall [Tickhill]	1·25	— ·46	·47	4	14	65·0	30	22·0	1	14	...
VIII.		Manchester (Plymouth Grove)	1·86	+ ·15	·32	29	12	60·0	30	30·0	17	4	20
IX.		Wetherby (Ribston Hall) ...	2·15	+ ·30	·81	5	10	...	...	...	...	...	...
,,		Skipton (Arncliffe)	2·64	— ·79	·43	29	17	57·0	30	27·0	13	10	...
,,		Hull (Pearson Park)	1·82	— ·10	·65	5	15	...	...	..	...	..	...
X.		Newcastle (Town Moor)	1·79	— ·04	·57	5	16	...	...	...	...	...	...
,,		Borrowdale (Seathwaite)......	7·63	+ ·49	2·10	3	15	...	...	...	...	...	...
XI.	WALES.	Cardiff (Ely)	...	...	...	...	...	...	...	...	...	...	...
,,		Haverfordwest	2·86	+ ·23	·85	2	10	58·8	28	27·0	1	5	8
,,		Carno (Tybrith)	3·63	+ 1·08	·88	3	13	53·0	27	21·0	11	23	...
,,		Llandudno	1·42	— ·39	·30	5	11	58·0	30	31·0	1	1	...
XII.	SCOTLAND.	Cargen [Dumfries]	1·94	— ·29	·91	3	9	56·8	30	24·6	1	10	...
,,		Jedburgh (Sunnyside)	1·05	— ·65	·34	29	7	55·0	15	21·0	1	10	...
XIV.		Old Cumnock	1·41	— ·72	·26	4	12	...	...	...	...	...	...
XV.		Lochgilphead (Kilmory)......	1·50	— 1·31	·38	30	10	...	...	...	...	...	...
,,		Oban (Craigvarren)	1·33	...	·41	30	10	55·9	23	28·4	8	2	...
,,		Mull (Quinish)	1·46	— 1·52	·50	30	8	...	...	...	...	...	...
XVI.		Loch Leven Sluices	·90	— 1·32	·30	6	7	...	...	...	...	...	...
,,		Dundee (Eastern Necropolis)	1·30	— ·75	·35	5	10	61·0	30	27·8	1	4	...
XVII.		Braemar	1·63	— ·79	·32	3	10	54·2	30	17·0	1	18	29
,,		Aberdeen (Cranford)	·63	...	·20	20	15	62·0	30	29·0	19	5	..
XVIII		Strome Ferry	1·34	— 1·58	·29	30	8	...	..	...	...	...	...
,,		Inverness (Culloden)	·50	— ·54	...	...	...	57·0	30	26·0	1, 8	9	29
XIX.		Dunrobin	·54	— 1·19	·20	15	6	53·5	30	30·0	24	2	..
,,		S. Ronaldsay (Roeberry)......	·72	— ·89	·22	30	13	55·0	30	31·0	2, 28	4	.
XX.	IRELAND.	Dromore Castle	2·47	— 1·14	·44	1	11	62·0	24	31·0	8, 26	2	...
,,		Waterford (Brook Lodge) ...	2·35	— ·12	·52	3	10	61·0	29	30·0	10	3	..
,,		O'Briensbridge (Ross)	2·16	...	·85	3	10	62·0	30	32·0	8, 26	2	...
XXI.		Carlow (Browne's Hill)	1·62	— ·66	·37	1	13	...	...	...	...	...	...
,,		Dublin (FitzWilliam Square)	1·55	— ·57	·48	3	14	65·7	30	33·1	10	0	12
XXII.		Ballinasloe	2·61	+ ·27	·79	3	14	58·0	30	26·0	8	8	...
,,		Clifden (Kylemore)	3·64	...	1·12	12	16	..	...	...	...	...	...
XXIII		Waringstown	2·74	+ ·32	1·09	1	14	63·0	30	26·0	25	13	22
,,		Londonderry (Creggan Res.).	1·48	— ·76	·39	30	15	...	...	...	...	..	...
,,		Omagh (Edenfel)	2·42	+ ·19	·70	3	14	55·0	18*a*	...	..	4	15

a And 26, 30.

+ Shows that the fall was above the average ; —that it was below it.

METEOROLOGICAL NOTES ON APRIL, 1891.

ABBREVIATIONS.—Bar. for Barometer; Ther. for Thermometer; Max. for Maximum; Min. for Minimum; T for Thunder; L for Lightning; T S for Thunderstorm; R for Rain; H for Hail; S for Snow.

ENGLAND.

STRATHFIELD TURGISS.—With the exception of the first week, a dry month, and at times very cold, but with a rapid rise in temperature on the 30th, and much wind, Solar halo on the 2nd.

ADDINGTON.—Another month of little rainfall; the greater part of it fell in a very short time after five o'clock on the afternoon of the 4th, causing the brook to overflow its banks. The R for the past six months, 7·29 in., is unusually little; all through the month the nights were cold and often frosty, keeping vegetation of all kinds much in check.

BURY ST. EDMUNDS, WESTLEY.—Very cold, with sharp frosts for the time of year, till the last three days of the month; 18 days of northerly wind. In spite of the cold, summer birds returned at their usual time.

LANGTON HERRING.—A fine, dry, but cold month, with the smallest R for April during 20 years. The mean temp. was 2°·2 below the average of 19 years. Solar halos on 1st, 21st and 26th. Fogs on 6th, 29th and 30th.

BODMIN.—A cold month, not seasonable. Very rough night on the 30th.

STROUD, UPFIELD.—Season very backward, owing to cold winds and low temperature. Great promise of fruit in the orchards.

WOOLSTASTON.—A cold backward month, with a good deal of frost. S fell 1st and 7th; T on 5th and T and H on 6th. Mean temp 42°·5.

ORLETON.—A very cold, cheerless month; mean temp. more than 4° below the average of 30 years, and with two exceptions (1879 and 1888), the lowest in April since 1860. Maximum at or above 60° on the last four days only; T on the 6th.

LEICESTER, BARKBY.—Cold and dry till the last few days. R still very deficient, and the water supply at Leicester nearly collapsed during the month.

HESLEY HALL.—Vegetation of all kinds very backward. R much needed; fields all bare, scarcely a bit of anything for the stock to eat; cold cutting N. and N.E. winds prevailing all the month.

MANCHESTER, PLYMOUTH GROVE.—The temp. was the lowest in April for 23 years, excepting 1879, when it was the same. Mean. temp. 44°; S and Sleet on the 2nd and 8th, and thick fog on 14th and 18th. Upon the whole a fine month.

HULL, PEARSON PARK.—The weather during the month was generaly cold, E. or N.E. winds prevailing. The afternoons and evenings were much less cloudy than the mornings.

WALES.

HAVERFORDWEST.—Seasonable wet weather prevailed during the first six days, after which the weather became very fine, with much bright sunshine. Cold generally, with sharp ground frosts during the last fortnight, with prevailing winds from N. and N.E. The month ended wet. Temp. below the mean.

SCOTLAND.

CARGEN.—A very cold month; the mean temp. 42°·1, being the lowest recorded, with the exception of 1887, when the mean was 41°·2. Easterly winds prevailed for 22 days. Only ·08 in. of R fell between the 5th and 29th. The R for the first four months of the year has been only 8·12 in. while the average for the period is 14 in., and the want of water is felt in some parts of the district. All vegetation exceedingly backward. Sunshine 21 hours below the average. T on 30th.

JEDBURGH.—The general character of the weather was cold and ungenial, with little sunshine and much cold wind. There was little vegetation, and from the total want of grass, stock has suffered much. All cereal crops have been got in well, for which the dry state of the ground has been favourable.

OBAN.—A very dry month, with a large amount of sunshine, and much cold wind. Growth much retarded, and sheep suffering for want of pasture.

INVERNESS, CULLODEN.—A very dry month. Temp. below the average, and all pasture very late.

S. RONALDSAY, ROEBERRY.—A very fine month, rainfall much below the average.

IRELAND.

WATERFORD, BROOK LODGE.—A good deal of east wind. Mean temp. 45°·2. Lunar Halo on 16th.

O'BRIENSBRIDGE, ROSS.—A beneficial fall of R occurred on the first four days, after which cold N.E. winds prevailed for most of the month.

DUBLIN.—Cold, rather dry and March-like. Mean temp., rainfall and rainy days, all below the average. On only one day did the temp. rise above 60° in the shade. No S or sleet, but H fell on 1st and 7th.

BALLINASLOE.—A very harsh and cold month, with strong E. and N.E. winds up to the 29th. No vegetation.

EDENFEL.—An ungenial month throughout; raw and cold when wet, harsh when dry. Easterly winds on 22 days. Hardly any vegetation. Hedges brown to the close. The smallness of the rainfall since January 1st (7·45 in.) has only been approached in 27 years, by 1875 and 1879, years also deficient in temp. till May, when the former changed for the better and became an abundant year, but the latter maintained its disastrous character to its close; so we can deduce nothing from the similarity.

THE GREAT SNOWSTORM OF MARCH, 1891.

WE have three facts, or groups of facts to add to the article in our last:—

(1). A very interesting popular shilling book has been published by Simpkin's, entitled, "The Blizzard in the West, March, 1891," with many illustrations from photographs.

(2). Another death from exposure occurred at Chelsham, near Croydon.

(3). We are able to extend our list of snow equivalents.

		Depth, Snow.	Water.	Ratio.
Crowborough Obs., Sussex...	C. L. Prince	6·00 ...	1.30 ..	5 : 1
Camden Sq., Middlesex......	G. J. Symons......	5·00 ...	·55 ...	9 : 1
Edith Rd., Kensington	G. von U. Searle	5·00 ...	·45 ...	11 : 1
Parkstone, Poole, Dorset ...	R. H. Barnes......	4·00 ...	·37 ...	11 : 1
,, ,, ,, ...	,, ,,	6·00 ...	·49 ..	12 : 1
Llanvihangel, Monmouth......	Col. Sturt	10·00 ...	·83 ...	12 : 1
York	J. E. Clark.........	5·00 ..	·31 ...	16 : 1
Bridgewater	H. Corder	6·00 ...	·33 ...	18 : 1

The mean being 11·8 : 1, or say 12 : 1, *i.e.*, just about the average.

MERLE'S MS., 1337-1344.

IT will probably be of interest to state that a sufficient number of subscribers has been obtained to justify publication, that the translation is finished and printed. As there has been some difficulty in the photographic reproduction, the order for printing will not go until May 20th, so that additional names can be received up to that date. The volume will be a very thin folio—about 15 inches by 10 inches—the photographs themselves being about 11 inches by 7 inches.