

To the British Meteorological Society
from W. Glaisher

On the Meteorology of England in the year 1847. By JAMES GLAISHER, Esq., of the Royal Observatory, Greenwich.

THE meteorological returns for the year 1847 furnished to the Registrar-General were from about thirty different stations, situated between the latitudes of $51\frac{1}{2}^{\circ}$ and 55° , and between the longitudes of $5\frac{1}{4}^{\circ}$ W. and $1\frac{1}{4}^{\circ}$ E. of Greenwich. The elevations of the different places varied from 30 feet to 350 feet above the level of the sea.

The monthly returns in each quarter were published in their respective quarterly reports, but only the monthly values corresponding to the times of the observations, and not those showing the mean values for the month; these were reduced to mean values for the formation of the quarterly tables; but the corrections used in their reduction were those deduced from three years' observations only; since that time I have formed tables from the five years' Greenwich observations ending December 31, 1845*, and have reduced the observations again by these values. The true monthly values thus found will probably appear in a future Annual Report of the Registrar-General.

On discussing the true monthly values, it was found that the temperature of the air decreased from the month of January to that of February at all places south of the latitude 52° ; that at places situated near this parallel the temperatures of these two months were nearly the same, and that north of this parallel there was an increase of temperature from January to February. Therefore the coldest month in the year, at places whose latitude was less than 52° , was February, and at places north of this parallel was January. The hottest month at all places was July. By taking the monthly means from the mean annual temperature, the annual variation is shown. It was found to be a single progression, having one ascending branch and one descending branch, being nearly identical with that shown in the tension of vapour. This evidence is conclusive upon the dependence of the monthly march of the vapour upon the temperature; each element has one ascending branch and one descending branch, and the march is harmonious.

The only other circumstance with respect to temperature to which I need allude, is the fact, that whilst the decrease of temperature month by month proceeded regularly in the

* See Philosophical Transactions, part i. 1848.

counties of Cornwall and Devonshire, and also, though at a less rapid rate, in the northern latitudes, the temperatures of September and October at intermediate places were nearly of the same value.

It was found that the months from March to July were less humid than the average for the year, and that the remaining months were more humid than the yearly average. The months of March to July are those distinguished by the temperature of the air increasing, and those from August to January or February by a decreasing or stationary temperature. The places situated in the counties of Cornwall and Devonshire were less humid than elsewhere; for notwithstanding the greater amount of vapour contained in the same mass of air in those counties to that in other places, yet the temperature increased more rapidly than the air received the addition to its vapour necessary to keep an equal degree of humidity.

The following Table contains the mean of all the monthly values of each element:—

From the numbers in this table the following values have been deduced for the year 1847:—

The mean pressure of the atmosphere of dry air at the level of the sea was 29.641 inches. This value applies to all parts of the country.

The mean pressure of the atmosphere of vapour in latitude $51^{\circ} 30'$ was 0.319 inch; and this value seems to diminish 0.010 inch for an increase of 1° in latitude.

The mean temperature of the air at the level of the sea in latitude $51^{\circ} 30'$ was $50^{\circ} 0'$; and this value at a uniform level was found to vary 1° very nearly for a change of 1° of latitude.

No certain law can be deduced from the observations of 1847, representing the excess of the temperature of the air above those of evaporation and dew-point; depending upon the difference of latitude, it seems however that the excess becomes smaller as we proceed north; but the observations of the wet-bulb thermometer during the early part of the year 1847 were unsatisfactory in many places, and the following is all the information I can give in this respect:—

The mean excess of temperature of the air above that of evaporation was $3^{\circ} 0'$, and above that of the dew-point was $5^{\circ} 6'$, in the counties of Cornwall and Devonshire;

The mean excess of temperature of the air above that of evaporation was $2^{\circ} 2'$, and above that of the dew-point was $4^{\circ} 7'$, at places situated in the vicinity of the sea;

The mean excess of temperature of the air above that of

Meteorological Table for the Year 1847.

Name of place.	Reading of barometer.	Elastic force of vapour.	Pressure of dry air.	Temperature of air.		Mean temperature of				Temperature of air.				Wind.		Amount of cloud.		Rain.		Deductions relative to humidity.				Height above the level of the sea.
				From self-registering thermometer.	From dry thermometer.	Evaporation.	Air above that of evapo-ration point.	Air above that of dew-point.	Dew-point.	Highest.	Lowest.	Range in year.	Mean monthly range.							Mean daily range.	Average strength.	General direction.	Number of days it fell.	
Helston	29.834	0.358	29.476	50.6	52.1	50.1	2.0	4.1	47.9	88.0	25.0	63.0	29.3	11.0	1.3	s.w.	5.9	152	38.7	4.1	0.6	0.874	533	106
Truro	30.002			49.9						73.0	27.0	46.0	22.7	8.2	1.1	s.w. & n.w.		185	46.5					
Torquay	29.830	0.326	29.504	51.3	51.6	48.4	3.2	6.3	45.3	80.0	26.0	54.0	26.5	10.4	2.3	n.s. & s.w.		160	27.2	3.7	0.9	0.807	536	120
Exeter	29.695	0.311	29.384	49.5	51.2	47.4	3.8	7.5	43.7	77.5	18.0	59.5	31.9	13.5		n. & e.		150	30.6	3.5	1.1	0.793	533	160
Brighton	29.939	0.321	29.618	47.6	49.4	44.4	2.1	4.4	43.9	76.0	24.0	52.0				n.e. & s.w.	6.0	133		3.6	0.6	0.867	542	140
Chichester	29.635	0.313	29.622	47.8						44.0	43.8	18.0	64.0	32.0	13.6				20.8					
Uckfield	29.876	0.320	29.556	49.2	51.3	47.5	3.6	7.2	44.3	98.0	1.0	97.0	47.7	18.7				121	17.6	3.6	1.1	0.795	537	180
Beckington	29.725	0.325	29.400	45.2	48.3	46.7	1.6	3.3	45.0	88.0	5.0	83.0	46.7		1.3	s.s.w.	4.9	151	28.7	3.7	0.5	0.894	538	265
Royal Observatory, Greenwich	29.813	0.319	29.494	49.7	49.7	46.9	2.8	5.7	44.0	86.0	10.2	75.8	39.4	16.1		s.s.w.	6.8	128	17.6	3.6	0.8	0.836	538	159
Lewisham		0.309		49.8	49.9	46.6	3.3	6.6	43.0	88.0	6.0	82.0	40.8	16.4	1.3	s.w.	4.9	140	18.7	3.5	0.9	0.811		40
Walworth	29.831	0.308	29.523	49.1						6.7	42.4	88.0	12.0	76.0	2.4	s.w.	6.3	149	14.7					32
Hereford	29.461			48.1														137	34.0					
Cambridge	29.922	0.317	29.605	48.7	49.0	46.3	2.7	5.4	43.6	86.7	18.7	68.0	38.5	17.5		variable.	6.9	148	19.6	3.3	0.9	0.817	541	88
Derby	29.705	0.313	29.392	47.2						81.0						variable.	6.9	168	28.2					39
Highfield House	29.761	0.325	29.436	49.3	50.2	47.5	2.7	5.3	44.9	88.0	20.0	68.0	34.7		1.8	s.w.	6.1	178	25.0	3.7	0.8	0.841	539	103
Liverpool	29.811	0.289	29.592	49.6	46.9	44.5	2.4	5.0	41.9	76.8	26.8	50.0	25.1	8.5	1.9	n.w.	6.7	177	31.6	3.3	0.6	0.846	543	37
Whithaven	29.722	0.299	29.423	47.6						45.1	21.1	4.5	42.7	79.0	24.5	54.5	s.w.	1.91	42.9	3.2	0.6	0.867	539	
Durham	29.530	0.272	29.258	45.7	46.4	43.6	2.8	6.2	40.2	83.2	17.2	66.0	33.5	12.0				134	15.9	3.1	0.8	0.812	536	340
Newcastle	29.749			44.8						77.0	21.0	56.0				s.w.		130	24.7					121

evaporation was $2^{\circ}7$, and above that of the dew-point was $6^{\circ}9$, at places situated inland.

The highest readings of thermometer occurred at Uckfield, Helston, Beckington, Lewisham and Walworth respectively.

The mean yearly range of temperature in the counties of Cornwall and Devonshire was $55^{\circ}6$, at places in the vicinity of the sea was $52^{\circ}3$, and in latitude $51^{\circ}30'$ was $78^{\circ}0$. This value diminished by about 5° for an increase of 1° in latitude.

The places of greatest yearly range were Uckfield, Beckington, Lewisham, Walworth and Greenwich respectively.

The places of least yearly range were Truro, Liverpool, Brighton, Torquay and Whitehaven.

The mean monthly range of temperature in latitude $51^{\circ}30'$ was 40° ; and this value seemed to diminish 3° for every increase of 1° in latitude.

The places of greatest monthly ranges were Uckfield, Beckington, Lewisham, Greenwich and Cambridge respectively.

The places of least monthly ranges were Truro, Liverpool, Torquay and Whitehaven respectively.

The mean daily ranges were greatest at Uckfield, Cambridge, Lewisham and Greenwich respectively.

The places of least daily ranges were Truro, Liverpool, Whitehaven and Torquay respectively.

The mean daily ranges in latitude $51^{\circ}30'$ were $16^{\circ}1$; and this value diminished by about 1° for an increase of 1° of latitude.

With respect to the average strength of the wind, I can speak with no confidence. I believe no two observers have estimated its value upon the same scale.

The prevailing direction of the wind in the counties of Cornwall and Devonshire was north-east and south-west, at Liverpool it was north-west, and at all other places it was south-west.

The amount of cloud may be considered to have been equal at all places, and such as to cover about three-fifths of the sky.

The average number of days in which rain fell was 152; this number was greatly exceeded at Truro and at Whitehaven, and was much less between the latitudes of 51° and 52° .

The mean amount of rain fallen in the counties of Cornwall and Devonshire was 35.8 inches, at Liverpool and Whitehaven was 37.3 inches, and at all other places was 22.2 inches. This value was exceeded at Beckington, Hereford and Derby. The places at which the smallest amounts of rain fell are Walworth, Durham, Uckfield, Greenwich and Lewisham.

The mean weight of water mixed with a cubic foot of air was 3.8 grains in the counties of Cornwall and Devonshire, and 3.5 grains at other places.

The mean additional weight required to saturate a cubic foot of air was 0.9 grain in the counties of Cornwall and Devonshire, and 0.7 grain at other places.

The mean degree of humidity was 0.825 in the counties of Cornwall and Devonshire, and 0.839 at other places.

The mean weight of a cubic foot of air at all places at the level of the sea was 541 grains.

The preceding results are chiefly for one point only, viz. that of the Royal Observatory at Greenwich reduced to the level of the sea. To render the results most generally useful, I have deduced the following formulæ, applicable to any place in England, taking into account the irregularities of the formation of the surface of the soil, and the law of the decrement of heat with increasing elevation.

The pressure of dry air at any place in England in the year 1847 was

$$29.641 \text{ in.} - \frac{\text{height of place in feet above the level of the sea}}{82 \text{ inches } \approx 20 \text{ feet}}$$

The pressure of water was $0^{\text{in}}.319 + (51^{\circ}30' - \text{latitude}) \times 0.010$ inch.

The sum of the two preceding formulæ gives the reading of the barometer.

The temperature of the air at any place in England may be calculated from the formula—

$$50^{\circ}0 + (51^{\circ}30' - \text{latitude}) \times 1^{\circ} - 0.00345^{\circ} \times \text{height of place in feet above the level of the sea.}$$

The observations are not sufficient to deduce the term depending upon longitude; its coefficient however would be very small, and in the present state of our knowledge may be neglected.

The approximate yearly range of temperature may be calculated from the formula—

$$78^{\circ} + (51^{\circ}30' - \text{latitude of place}) \times 5^{\circ}.$$

The mean monthly range of temperature may be calculated from the formula

$$40^{\circ} + (51^{\circ}30' - \text{latitude of place}) \times 3^{\circ}.$$

The mean daily range of temperature may be computed from the formula

$$16^{\circ}2 + (51^{\circ}30' - \text{latitude of place}) \times 1^{\circ}.$$

The approximate weight of a cubic foot of air may be calculated from the formula

$$541 \text{ grains} - \frac{\text{height of place in feet above the level of the sea}}{82 \text{ inches } \approx 20 \text{ feet}} \times 18$$

It is desirable to compare the results deduced by means of the preceding formulæ with the observed results, not only for the purpose of testifying their accuracy, but also to examine the accuracy of the several instruments which have been used at the different stations.

The annexed table shows the results of this comparison.

In viewing the differences shown in the fourth and tenth columns between the observed and calculated pressures, it is evident that at most places the instruments are good. When we view the differences which some of the places present, we shall readily see that the instruments at those places need correction. The barometer at Exeter seems to read too low by 0.103 inch; that at Uckfield to read too high by 0.131 inch; and that at Derby to read too low by 0.193 inch. These corrections should be applied to the readings of these instruments till the true values are determined by a direct comparison with a standard.

I proceed to consider the numbers in the thirteenth column, showing the differences between the observed and calculated annual temperatures of the air. These differences are generally small, and quite within the probable errors of the instruments themselves. This formula therefore may be considered to give the true temperature; and from it the mean temperature of any place in England may be calculated for the year 1847. The differences at Brighton and at Beckington are large, and the annual temperatures as determined at those places are either erroneous, or those places are subjected to a peculiar local influence. Let us turn for a moment to the annual temperature as determined from the corrected readings of the dry bulb thermometer in the yearly table at both these places. The annual temperatures, as thus deduced, are nearer the computed values than those determined from the maximum and minimum thermometers; and it would seem that the self-registering instruments are in error, and that the differences are not due to local disturbances. At Derby and at Nottingham the instruments require correction. At Liverpool the difference shown would seem to be due to locality.

The differences in the thirteenth column, at those places situated in the counties of Cornwall and Devonshire, are small; therefore the annual temperatures of these places are only those due to their latitude. In turning our attention to the 16th, 19th, and 22nd columns, we at once perceive the cause of the loveliness of the climate of those counties to be the uniformity of their temperature. Their yearly, monthly, and daily ranges are respectively 28° , 15° , and 7° less than those due to their latitude.

Comparison of the Computed Values of the Meteorological Elements for the Year 1847, with the Observed Values.

Name of place.	Pressure of dry air.			Pressure of vapour.			Reading of barometer.			Temperature of air.			Yearly range of temperature.			Monthly range of temperature.			Daily range of temperature.		
	Observed.	Computed.	Observed — Computed.	Observed.	Computed.	Observed — Computed.	Observed.	Computed.	Observed — Computed.	Observed.	Computed.	Observed — Computed.	Observed.	Computed.	Observed — Computed.	Observed.	Computed.	Observed — Computed.	Observed.	Computed.	Observed — Computed.
Helston	29.476	29.512	-0.036	0.358	0.333	+0.025	29.834	29.845	-0.011	50.6	51.0	-0.4	63.0	85.0	-22.0	29.3	44.2	-14.9	11.0	17.6	-6.6
Truro	29.504	29.495	+0.009	0.326	0.331	-0.005	29.830	29.826	+0.004	49.9	51.0	-1.1	46.0	84.0	-38.0	22.7	43.6	-20.9	8.2	17.4	-9.2
Torquay	29.384	29.471	-0.087	0.311	0.327	-0.016	29.695	29.798	-0.103	51.3	50.8	+0.5	54.0	84.0	-30.0	26.5	43.6	-17.1	10.4	17.4	-7.0
Exeter	29.618	29.568	+0.050	0.321	0.326	-0.005	29.339	29.894	-0.555	49.5	50.4	-0.9	59.5	82.0	-22.5	31.9	42.4	-10.5	13.5	17.0	-3.5
Brighton	29.622	29.622	0.000	0.313	0.326	-0.013	29.835	29.835	0.000	47.6	50.2	-2.6	52.0	81.5	-29.5	41.2	41.2	0.0	16.9	16.9	0.0
Chichester	29.556	29.421	+0.135	0.320	0.324	-0.004	29.876	29.745	+0.131	47.8	49.9	-2.1	64.0	81.5	-17.5	32.0	41.2	-9.2	13.6	16.9	-3.3
Uckfield	29.400	29.318	+0.082	0.325	0.320	+0.005	29.725	29.638	+0.087	45.2	49.3	-4.1	97.0	80.5	+16.5	47.7	41.5	+6.2	18.7	16.7	+2.0
Beckington	29.494	29.447	+0.047	0.319	0.319	0.000	29.813	29.766	+0.047	49.7	49.5	+0.2	83.0	78.5	+4.5	46.7	40.3	+6.4	16.3	16.3	0.0
Greenwich	29.523	29.601	-0.078	0.309	0.319	-0.010	29.831	29.766	+0.065	49.8	49.9	-0.1	75.8	78.0	-2.2	39.4	40.0	-0.6	16.1	16.2	-0.1
Lewisham	29.523	29.601	-0.078	0.308	0.319	-0.011	29.831	29.766	+0.065	49.8	49.9	-0.1	82.0	78.0	+4.0	40.8	40.0	+0.8	16.4	16.2	+0.2
Waltham	29.523	29.601	-0.078	0.308	0.319	-0.011	29.831	29.766	+0.065	49.8	49.9	-0.1	76.0	78.0	-2.0	34.7	40.0	-5.3	16.2	16.2	0.0
Hereford	29.605	29.533	+0.072	0.317	0.312	+0.005	29.461	29.461	0.000	48.1	48.1	0.0	75.5	75.5	0.0	38.5	38.5	0.0	15.7	15.7	0.0
Cambridge	29.392	29.593	-0.201	0.313	0.305	+0.008	29.705	29.898	-0.193	48.7	49.1	-0.4	68.0	74.5	-6.5	38.5	37.9	+0.6	17.5	15.5	+2.0
Derby	29.436	29.518	-0.082	0.335	0.305	+0.030	29.705	29.898	-0.193	47.2	48.5	-1.3	71.0	71.0	0.0	35.8	35.8	0.0	14.8	14.8	0.0
Highfield House	29.592	29.596	-0.004	0.289	0.300	-0.011	29.881	29.896	-0.015	49.6	48.0	+1.6	68.0	70.5	-2.5	34.7	35.5	-0.8	14.7	14.7	0.0
Liverpool	29.423	29.423	0.000	0.299	0.289	+0.010	29.722	29.722	0.000	47.6	47.6	0.0	50.0	69.0	-19.0	25.1	34.0	-8.9	8.5	14.3	-5.8
Whitehaven	29.258	29.226	+0.032	0.272	0.287	-0.015	29.530	29.513	+0.017	45.7	45.8	-0.1	54.5	63.0	-8.5	28.6	31.0	-2.4	10.3	13.2	-2.9
Durham	29.469	29.495	-0.026	0.274	0.274	0.000	29.749	29.769	-0.020	44.8	46.1	-1.3	66.0	62.0	+4.0	33.5	30.4	+3.1	12.0	13.0	-1.0
Newcastle	29.469	29.495	-0.026	0.274	0.274	0.000	29.749	29.769	-0.020	44.8	46.1	-1.3	56.0	60.5	-4.5	29.5	29.5	0.0	12.7	12.7	0.0

I have already alluded to the influence of the sea in equalising the temperature of places in its vicinity in my remarks on the quarter ending June 30, 1847. It moderates the severity of winter and the heat of summer, but does not seem to exercise any influence over the mean annual temperature. Hence we perceive the same annual temperature may be distributed in various ways in the different seasons of the year.

At Uckfield, the yearly, monthly and daily ranges are in excess, which must be owing to local perturbations. By reference to column 13, it will be seen that the annual temperature has been uninfluenced by these large ranges.

The only other places at which considerable differences are shown between the calculated and observed ranges are Whitehaven and Liverpool; and the smallness of the ranges at those places are evidently to be attributed to the vicinity of the sea.

In conclusion, I have merely to remark, that I am persuaded the spirit of the above method of reducing meteorological observations, and deducing from them general formulæ, will some day lead to empirical laws, showing the reciprocal dependence of each subject of research. I would, however, impress upon observers generally the absolute necessity of using good instruments, and ascertaining their errors by comparison with standards; such would save me a great deal of labour and anxiety, which I have experienced in the past year. These exertions, it is evident, could not be long continued; and it must be borne in mind, that no system of calculation can deduce good results from imperfect observations. I must beg, however, to offer my sincere thanks to the gentlemen who have furnished the observations, for their ready acquiescence at all times to my wishes.

This is the first annual report upon the meteorology of England. May it be followed by many, more ably conducted and more valuable to meteorology!