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XII. *Meteorological Observations for Portions of the Years 1836 and 1837, made at Bermuda; and a Notice of an Aurora Borealis seen in low Latitudes. By Lieut.-Col. A. EMMETT, Royal Engineers.*

To the Editors of the Philosophical Magazine and Journal.
GENTLEMEN,

THE great attention now given to meteorology induces me to forward for the *Philosophical Magazine* a summary of the observations taken by me within the period of twelve months*. Every attention has been given to their accuracy; and from the character of the instrument-maker, Mr. Newman, I think they may be received with confidence. I am well aware that the observations of twelve months are insufficient for establishing many data, yet there are two or three points which merit attention, particularly that of the horary changes.

I shall not at present trespass further on your pages than to notice that a most splendid aurora borealis was seen here on the 25th of January, as also even down to the tropics, respecting which I transcribe an extract from the journal of Captain Willis of H.M.S. *Cruiser*, which he was kind enough to send me from Jamaica:

“In lat. 22° north, long. 57° west, at 8 p.m., the aurora borealis was observed very brightly; it began at 8 by a red flush suddenly spreading itself over a great part of the northern hemisphere, extending in altitude to about 30° ; then a number of streamers showed themselves shooting upwards with great brilliancy. They continued about fifteen minutes, then ceased, leaving that part of the sky for a time blood red.”

The appearance here was very similar, but more extensive and of longer continuance.

I remain, &c.

Bermuda, July 11, 1837.

A. EMMETT,
Lieut.-Col., R. E.

P.S. This aurora appears to have been seen over a large extent of North America.

* Lieut.-Col. Emmett's observations for the period from July 1 to September 30, 1836, having already appeared, in the paper prepared by Dr. Dalton, inserted in our last volume, p. 449, we have omitted them in the tables which follow; retaining, however, the means for the entire six months, from July 1 to December 31, 1836.—EDIT.

Meteorological Observations at St. George's, Bermuda, from 1st of October to 31st of December, 1836.

Months.	Barometer.				Temperature.				Temperature of Sea.	Hygrometer.		Rain.			Storms or Gales.	Prevailing Winds.	
	Mean.	Max.	Min.	Diff.	Mean.	Max.	Min.	Diff.		Dew Point.	Vapour.	Day.	Night.	Total.			
October.	29.978	30.282	29.774	.508	73.07	78.5	62	16.5	78.5 75	64	.597	6.16	11.08	17.24	11	1st SW. 2nd SE.	Lightning 11.
November.	29.990	30.320	29.530	.790	65.9	73.	53	20	67.5 62.5	54.8	.440	.77	2.53	3.30	11	1st NW. 2nd SE.	Lightning 2.
December.	30.150	30.620	29.840	.780	60.55	70.25	51	19.95	64 61	54	.429	.43	2.02	2.45	4	SE. SW. NW. equ.	Bar. 30.620 on 20th. Wind E. to SE. & strong.
Means July 1 to Dec. 31.	30.042	30.375	29.760	.615	71.6	77.27	62.3	14.9	73.1	64	.597	7.36	15.63	22.99	32		

Barometer 60 feet above the sea, for which no correction is made. The *monthly means* are corrected for capacity, capillary, &c. and then reduced to 32° Fahr. The mean of 9 a.m. and 4 p.m. (those having been found the periods of greatest and least elevation) are taken for the mean of the day; and if not then taken 1 p.m. is substituted. Maximum and minimum heights are not corrected. Read off by a magnifier on the convexity of the column; light just excluded. Temperature: means taken from self-registering thermometer, once in twenty-four hours.

Dew-point, perhaps too high, taken by moist-bulb thermometer compared occasionally with Dalton's method.

Summary from 1st of January to 30th of June 1837.

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Months.	Barometer.				Temperature.				Temperature of Sea.	Hygrometer.		Rain.			Gales.	Prevailing Winds.	
	Mean.	Max.	Min.	Diff.	Mean.	Max.	Min.	Diff.		Dew Point.	Vapour.	Day.	Night.	Total.			
January.	29.762	30.280	29.394	.886	57.9	67.5	47	20.5	61 64	52.9	.413	.92	2.56	3.48	20	1st NW. 2nd SW.	Lightning, 5 days or nights.
February	30.065	30.482	29.732	.750	58.89	68.5	47.5	21	64 62	54	.429	.58	3.06	3.64	10	1st NW. 2nd SW.	Lightning, 2.
March.	29.999	30.320	29.444	.876	59.3	64.5	53	11.5	62 63	53.8	.426	1.67	2.38	4.05	6	1st NE. 2nd NW. 3rd N.	Lightning, 1.
April.	29.989	30.430	29.598	.832	62.8	71	55	16	62 68	56.2	.462	1.74	2.02	3.76	4	1st NW. 2nd SW.	Lightning, 1.
May.	30.139	30.350	29.936	.414	69.13	75	58.5	16.5	67 74	61.7	.554	3.03	.83	3.86	2 mod.	1st NE. 2nd SE.	Lightning, 4.
June.	30.006	30.390	29.762	.628	73.2	79.5	66.5	13	75 79.5	67.8	.672	3.18	5.35	8.53	2 mod.	1st SW. 2nd NW. 3rd SE.	Lightning, 10.
Mean.	29.993	30.375	29.644	.731	63.54	71	54.6	16.3	66.9	57.7	.485	11.12	16.2	27.32	44		
1837. Half year.	30.042	30.375	29.760	.615	71.6	77.27	62.3	14.9	73.1	64	.597	7.36	15.63	22.99	32		
1837.	29.993	30.375	29.644	.731	63.54	71	54.6	16.3	66.9	57.7	.485	11.12	16.2	27.32	44	Rain, last 9 months only.	
Mean of year.	30.017	30.375	29.702	.673	67.5	74.13	58.45	15.6	70	60.8	.538	18.48	31.83	50.31	76		

Comparison of Barometer at 9 a.m., 4 p.m., and 9 p.m.

Month. 1836.	No. of Observa- tions.	9 A.M.	4 P.M.	Diff.	No. of Observa- tions.	9 P.M.	4 P.M. higher than 9 A.M.
July.	24	30·162	30·149	·013	24	30·183	7
August.	23	30·138	30·108	·030	23	30·132	6
Sept.	18	30·140	30·107	·033	18	30·132	2
October.	18	30·066	30·034	·032	18	30·053	1
Nov.	26	30·062	30·031	·031	...	...	6
Dec.	30	30·224	30·188	·036	27	30·215	5
Mean.	139	30·132	30·103	·029	110	30·145	27
1837. } Jan.	30	29·892	29·832	·060	24	29·865	5
Feb.	27	30·132	30·101	·031	14	30·118	7
March.	30	30·075	30·032	·043	25	30·048	7
April.	23	30·027	30·007	·020	17	30·052	5
May.	22	30·136	30·128	·008	6	30·104	5
June.	24	30·075	30·054	·021	22	30·071	5
	156	30·057	30·025	·032	108	30·043	34
1836	139	30·132	30·103	·029	110	30·145	27
1837.	156	30·057	30·025	·032	108	30·043	34
Total } Mean.	295	30·094	30·064	·030	218	30·094	61

All the observations at 9 a.m. and 4 p.m. were taken on the same days; those at 9 p.m. not always so. No corrections are made. Occasionally, that is in the proportion of 1 to 5, the barometer is higher at 4 p.m. than at 9 a.m.

Time at Bermuda is not correctly kept, but during the hot season the critical hours appear to be between 8 and 9, and about 4; at other times half an hour nearer noon.

The horary difference exceeds in a very trifling degree that at Paris.

Various Memoranda.

Barometer used, Newman's iron cistern portable.

Thermometer, Newman's compared with one furnished as a standard, with his own.

Dew-point. The difference between the attached thermometer and the moist bulb multiplied by 2, and subtracted from the latter, gives that point nearly; but less dependence is to be placed on these columns than on any other.

Winds: relative Proportions.

1836.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
July.	...	...	1	19	9	44	10	10
August.	3	8	1	15	2	39	11	14
Sept.	4	24	8	24	11	10	3	6
Oct.	11	17	1	22	8	25	2	7
Nov.	4	12	4	18	3	10	2	32
Dec.	6	16	4	21	8	21	...	21
	28	77	19	119	41	149	28	90
1837. Jan.	...	3	2	1	3	27	10	47
Feb.	9	5	...	7	8	22	4	29
March.	19	26	1	...	4	16	1	24
April.	12	7	3	5	9	28	8	18
May.	4	23	9	19	12	9	8	8
June.	9	6	...	18	8	24	6	19
	53	70	13	56	44	126	37	145
1836.	28	77	19	119	41	149	28	90
	81	147	32	169	85	275	65	235

The winds are taken at sun-rise, noon, and sun-set, and collected and classed therefrom. They are often very irregular, and on many occasions have been at every point of the compass within twenty-four hours. They often freshen about 9 a.m., moderate after noon, and again freshen towards sun-set; but these changes are not general.

Calms of 24 or 36 hours occasionally occur in the months from June to September, but not often so long; but they are frequent for shorter periods, mostly in the afternoon.

General Observations on the Year.

Barometer. Greatest height, corrected and reduced, 30·664; least ditto, 29·414; greatest range, 1·25: highest with NE. and SE. winds; lowest, with NW. and SW.

Thermometer. Greatest observed power of common black bulb, 106°; greatest observed heat of ground, thermometer barely covered, 142°; sun's greatest force about 1 p.m.; hour of greatest heat 4 to 4½ in the hot season, and 3 to 3½ at other times. Dew-point, accords with the latter. Clear days, proportion 1 to 4 or 5. Halos, rare.

A. EMMETT,

Lieut.-Col. Royal Engineers.

XIII. On the Wave-surface in the Theory of Double Refraction.

By J. W. LUBBOCK, Esq., F.R.S.*

MR. TOVEY remarks, p. 524 of the last Number, that I have taken for granted that the differential equations of molecular attraction may be reduced to the form

$$\frac{d^2 \xi}{d t^2} = m \Sigma \left\{ \phi r + \psi (r) \Delta x^2 \right\} \Delta \xi.$$

I confess that the reasoning of Fresnel connected with this matter is to me by no means clear, but I presume the reduction will at all events be admitted to be possible in the manner pointed out by M. Cauchy in the *Nouveaux Exercices*, p. 11, the *axes of elasticity* being the principal axes of the curve of the second order given by the equation (36.), p. 12.

Instead of taking

$$\Delta g = \frac{d g}{d r} \Delta r + \frac{d^2 g}{1.2 d r^2} \Delta r^2 + \&c.,$$

I might have taken, in the manner of Mr. Kelland and of M. Cauchy,

$$\begin{aligned} g &= A \cos (n t - k r) & \frac{d^2 g}{d r^2} &= -k^2 g. \\ \Delta g &= -A \cos (n t - k r) (1 - \cos (k \Delta r)) + A \sin (n t - k r) \sin (k \Delta r) \\ &= -2 \sin^2 \left(\frac{k \Delta r}{2} \right) g + A \sin (n t - k r) \sin (k \Delta r). \end{aligned}$$

Neglecting the terms multiplied by $\sin (k \Delta r)$, for the reasons given by M. Cauchy, p. 10, if

$$a^2 = 2 m \Sigma \left\{ \phi r + \psi (r) \Delta x^2 \right\} \frac{\sin^2 \left(\frac{k \Delta r}{2} \right)}{k^2}.$$

* Communicated by the Author.