

Report on the Kodaikanal and Madras Observatories for 1899-1900.

The scheme for the reorganization of the Indian Observatories having come into operation from 1st April 1899, the Madras Observatory was from that date transferred from the Government of Madras to the Government of India, and the former Government Astronomer became Director of the Kodaikanal and Madras Observatories. Thus ended the connection between the Local Government and the Observatory which had lasted for 107 years, a period during which much useful work had been done, sometimes, indeed, in face of official discouragement, but usually with the sympathy and support of the Local Government. It remains to be seen whether the evident advantages of the direct connection with the Imperial Government will altogether make up for the drawbacks arising from the greater distance of the governing power.

The Kodaikanal Observatory.

2. *Staff*.—The following is the sanctioned staff of the Kodaikanal Observatory :—

Post.	Name.	Salary.
Director	C. Michie Smith, B. Sc.	Rs. 800 and free house.
1st Assistant	K. V. Sivarama Aiyar, M.A.	„ 150—250 Do.
2nd „	{ V. S. Somasoondrum, M.A.	„ 100—150 Do.
	{ S. Sitarama Aiyar, B.A.	
3rd „	{ M. B. Subba Rao, B.A.	„ 70—90 Do.
	{ G. Nagarajah Aiyar	
4th „	{ G. Nagarajah Aiyar	„ 50—70 Do.
	{ C. Theodore, B.A.	
Writer	Vacant	„ 30—50 Do.

The subordinate staff consists of a mechanic, two menial assistants, four peons and two lascars.

Mr. P. Ragava Chari, the 1st Assistant of the Madras Observatory, retired on superannuation pension on March 31st 1899, and the remainder of the staff were provided with appointments either at Kodaikanal or at Madras. In December Mr. Somasoondrum resigned his appointment to take up a post in the Revenue Department and the changes indicated above were made in consequence.

Much trouble was experienced at first in getting suitable men for the subordinate staff. The mechanic first appointed, who had received a special training at the School of Arts, Madras, took fright at the climate and remained only two days. The man next appointed came part of the way and then turned back. The man finally obtained has not the same qualifications as either of the men previously appointed. He was a lock-smith by trade and is a good rough workman who is capable of learning and has already made

progress in the use of the lathe. Of the peons first appointed, two who were pensioned sepoy, left after three days on the ground that the village was so far away that they could get no one to drink with. Natives who come up here from the plains at first find the climate very trying, but if they can be persuaded to stay for a few months they find that it is not nearly so bad as they at first thought. The appointment of a writer has not yet been made as there is no house for him to live in. Proposals were put before Government in April 1899 for building an additional house and for the appointment of a European Pensioner as a writer on an increased salary, but the matter has not yet been settled.

3. *Buildings and Instruments.*—The work on the buildings has progressed slowly during the year for reasons which have been dealt with elsewhere and need not be entered upon here. As soon as the towers for carrying the domes were ready, the Director personally undertook the erection of the domes. As no skilled workmen were provided he had with his own hands to do all the work that could not be done by a common native village carpenter or blacksmith. This included the driving of some 2,300 rivets. Both domes were practically completed by December. Before this time the whole of the buildings had been roofed in and the laboratory and computer's room were in use.

The 6-inch Cooke equatorial has been erected in the south dome and has been approximately adjusted. The mean time Kullberg clock and the sidereal-time Shelton clock have been erected in the Laboratory on solid stone piers. The former clock, which is a new one, has a very steady rate. It is fitted with electrical hourly and seconds contacts. The former are at present used only for making an hourly mark on the seismogram and for ringing a bell in the Director's house; but hereafter it is intended, if possible, to use them for marking the time on the sheets of all continuous recording instruments. The "Shelton" clock which is more than 120 years old, still keeps a very fair rate. It would not be good enough for Meridian work, but is quite satisfactory for the work for which it will be employed.

The re-erection of the iron shed built in Madras for holding the photo-heliograph was nearly completed at the close of the year. It has been placed at some distance to the north of the Observatory in a situation which though sheltered from the strongest winds, gives a clear view of the sun throughout the year from sunrise to nearly sunset.

4. *The Seismograph.*—The seismograph was removed from Madras in December and immediately on arrival was set up at Kodaikanal. The pier is founded on the solid rock in the room below the south dome. Since its erection here no large earthquake has been recorded by it, though it has been in good working order nearly the whole of the time. The following are the most important shocks recorded during the year:—

Ts. No.	Date.	Commencement G. M. T.	Duration first P. Ts.	Times of Maxima. G. M. T.	Amplitude. (seconds).	Duration.		REMARKS.
						H.	M.	
	1899	H. M.	M. S.			H.	M.	
12	April 3	8 43.6	...	...	...		37	Very slight.
13	4	3 59.1	...	...	...	About	3	Do.
14	4	5 29.7	...	...	...	"	4	Do.
15	9	7 25.6	...	...	...	"	3	Do.

Ts. No.	Date.	Commence- ment G. M. T.	Duration first P. Ts.	Times of Maxima. G. M. T.	Amplitude. (seconds).	Duration.	REMARKS.
16	1899 April 12	H. M. 16 34'0	M. S. ...	H. M. 16 36'0	0'5	H. M. 10	
	12	...	...	16 38'0	0'3		
16A	12	18 35'9	4 0	18 42'6 } 18 44'5 }	0'5 } 0'4 }	37'3	
17	13	4 50'2	3 0	4 56'0 } 4 59'4 }	0'5 } 0'5 }	20'4	
18	17	15 41'0	...	...	...	5	Very slight.
19	18	6 26'0	...	...	0'2	5	
20	19	5 20'5?	...	...	...	...	Very slight.
21	21	20 31'0	...	...	...	4 53	Severe tremor storm.
22	24	11 29'7	...	...	0'2	4	
23	25	9 29'8	...	...	...	5	Very slight.
24	25	14 15'4	...	14 16'4	0'7	5	
25	29	6 19'4	...	...	...	7	Very slight.
26	May 31	9 27'5	...	9 28'5	0'3	4'2	
27	June 19	2 42'1	...	2 42'1	0'4	7'4	
28	27	1 58'5	...	2 2'1	1'4	5	} Peculiar form.
29	27	2 42'0	...	2 44'1	2'6	7	
30	29	22 59'3	2 0	23 8'6	0'7	24	
31	July 9	19 12'8	1 0	19 17'0 } 19 19'0 }	1'2	26	
32	11	7 55'6	...	7 59'7	0'7 } 0'2 }	5	
33	12	2 29'3	1 0	2 36'4	0'2	16	} Maximum may have been lost sheet marked at 14h. 03m.
34	14	13 49'4	3 0	13 57'0 } 13 59'2 }	0'4 } 0'5 }	49	
35	Aug. 4	4 53'4	2 0	5 4'1	0'7	16	
36	17	20 35'0	1 0	20 53'2	0'8	1 18	
37	Sept. 1	10 58'6	2 0	11 0'9	0'1	5'2	
38	6	17 11'6	...	17 13'1	0'1	4	
39	10	17 28'3	2 0	18 3'2 } 18 12'5 }	1'0 } 0'7 }	?	Clock stopped about 18h. 36m.
40	15	7 40'01	Many	small	movements	1 20	
41	17	13 51'2	...	13 52'2	0'3	4	
42	Nov. 23	10 9'3	3 30	10 44'5	0'5	51	
43	24	18 51'8	5 0	19 20'5 } 19 25'8 } 19 29'4 } 19 32'0 }	0'7 } 0'5 } 0'4 } 0'4 }	1 12	

Instrument brought to Kodaikanal and began recording January 12th

1900:—

	1900							
8	Feb. 18	18 43'9	}	...	...	Dislocation	...	Earthquake heard and felt.
9	18	18 46'0						
10	20	20 50'4	2 0	20 54'1	0'5	22		
11	23	8 44'0	...	...	Dislocation	...	Earthquake heard and felt.	

On February 8th the Madras Presidency was visited by a shock of earthquake apparently more severe than any that has been experienced for many years. From the study of a large number of reports which have reached the Director, it appears that the centre of the disturbance lay about 15 miles west of Dharapuram in the Coimbatore District. The chief shock occurred at about 3h-6m-30s M. M. T. on the morning of the 8th. Near the centre the shock was strong enough to throw down houses and a considerable number of lives were lost. At greater distances, up to about 100 miles, in a south-easterly direction and 120 miles in a north-westerly direction it was strong enough to crack walls and shake tiles off the roofs. In the Director's new house at Kodaikanal all the arches were slightly cracked. The observatory, however, being much more strongly built, showed no traces of the shock. The seismograph was not working at the time but the shock was clearly marked by the Richard barograph. This shock was followed by a large number of other shocks of less intensity. Three of these shocks were recorded by the seismograph as slight dislocations of the trace, but it must be remembered that Milne's seismograph is intended for recording the effects of distant earthquakes and cannot respond freely to the rapid vibrations produced by near earthquakes.

5. *Observations and reductions.*—Observations have necessarily been a very minor part of the work of the past year. Sextant observations for time, for rating the clocks and chronometer, have usually been taken twice a week. A few observations have also been made for latitude and for setting up an azimuth mark. A number of preliminary observations have also been taken with Prof. Balfour Stewart's Actinometer and the size of diaphragm to be used has been finally fixed. Several complete series of observations have been made.

A close watch was kept for the Leonids on the morning of November 14th and the three following nights by the Director and the Assistants. The results were communicated in detail to Prof. E. C. Pickering of Harvard observatory, along with the observations made at Madras and some other places in India. A summary of the results was also communicated to the Royal Astronomical Society and published in the *Monthly Notices*, Vol. LX., p 262.

The printing of the *New Madras General Catalogue* was finished in November and the volume was partly distributed before the close of the year.

Tables for calculating refractions, vapour densities, and humidities for barometric pressures of about 23 inches not being available, a series of tables have been calculated for the range of pressure and temperature likely to be experienced at Kodaikanal. The refractions have been calculated as an extension of the Greenwich tables. If a suitable instrument were available, the Kodaikanal Observatory would be a most excellent place for making a series of observations on refraction.

6. *Library.*—Bookcases reaching from the floor to the ceiling have been erected on two sides of the library room of the Director's house, but an additional case is required before the books can be properly arranged. This is now in hand and will soon be ready.

Two hundred and eighty books and pamphlets were presented to the Observatory during the year.

7. *The Grounds.*—The grounds belonging to the Observatory amount to about 100 acres. The greater part of this is either bare rock or grass covered slopes. To reduce as far as possible the disturbing effect of the sunshine on

bare ground it will be well to cover the ground round the Observatory with trees and shrubs wherever this is possible. The past season has been a very unfavourable one for work of this kind, but a beginning has been made and some 1,500 trees have been planted.

8. *Meteorological*.—Readings of the barometer and rain-gauge were begun early in April, but the thermometer shed was not ready till May 2nd. After that date systematic observations were made three times a day at 8^h, 10^h, and 16^h. Till the end of December the barometer was placed in the Director's house as it could not be safely placed in the Observatory, but on the morning of January 1st it was transferred to the Observatory where the cistern is, approximately, at a height of 7,700 feet above sea level. The previous readings have been corrected for the difference of level. In addition to the standard mercurial barometer a Richard Barograph is in use. The hourly readings taken from the barograms are corrected by reference to the mean of the three daily readings of the standard, and the mean daily barometer reading is obtained from the hourly readings so corrected. A Richard Thermograph has been ordered for the Observatory, but has not yet been received. The tower for the anemograph has not yet been built and at present the wind direction is obtained by eye observations and the velocity from a small anemometer, the exposure of which is not quite satisfactory.

The year was undoubtedly a very abnormal one owing to the great deficiency of the rainfall during the last three or four months, but it may be of interest to give a few figures to indicate the nature of the climate, though it must be clearly understood that in certain respects future years may differ widely from the past. To obtain statistics for a whole year the observations have been taken from May 1899 to the end of April 1900. The main features are given in the following tables in Appendix I.

The highest wind velocity for any one day is 758 miles, but this is far from being a measure of the strongest winds experienced during short intervals. Speeds of above 50 miles an hour were noted several times, and winds of 30 miles an hour and upwards were common. A very striking feature of the climate is the extreme dryness of the air on a number of days during the period December to March. Thus, assuming the usual formula to be correct under these extreme conditions, which is unlikely, the relative humidity at 8 A.M. was only 4 per cent. on January 15th and 16th and it was from 5 to 8 per cent. on fourteen other mornings. The extremely large range of humidity experienced here is very trying to woodwork of all kinds. All cameras and dark slides, even if they have been in the tropics for years, require to be carefully examined for cracks at frequent intervals.

It should be noted that the meteorological observations here recorded do not represent exactly the conditions experienced in the part of Kodaikanal where most of the houses are situated since the observing station is 800 feet above the lake and more than 500 feet above all except a very few of the houses.

As a means of estimating the clearness of the lower stratum of the air, observations have been made regularly since July 18th of the visibility of the Nilgiris, distant some 80 miles in a north-westerly direction. The number of days

in each month when the Nilgiris were visible are classed under four headings which explain themselves:—

Month.	Very clear.	Visible.	Just visible.	Tops only visible.
July (13) days	8	1	3	—
August	2	5	11	—
September	5	7	12	—
October	2	4	5	—
November	3	9	2	—
December	13	11	1	3
January	11	11	3	2
February	1	3	7	3
March	0	1	8	2

The low visibility in February and March was chiefly due to smoke-haze from the burning grass on the hills. It has not been possible to carry on any systematic observations as to the clearness of the sky during the night, but experience shows that nights which are cloudy throughout are rare. In connection with this Observatory a Meteorological Station has been opened at Periyakulam about $3\frac{1}{2}$ miles from the foot of the hills. The horizontal distance between the two stations is about 10 miles and the vertical distance about 6,700 feet. This station was opened on January 1st, 1900. It will be supplied with a Richard barograph and a thermograph and probably with an anemograph, but at present the work is confined to eye observations.

KODAIKANAL OBSERVATORY, }
The May 1900.

C. MICHIE SMITH,
Director.

The Madras Observatory.

The following report has been submitted by Prof. R. L. Jones, Deputy Director of the Madras Observatory.

1. I was placed in charge of the Madras Observatory, under the Director Mr. C. Michie Smith, on the 1st April 1899.

2. On the same date the following appointments were made in connection with the Observatory:—

M. R. Ry. S. Solomon Pillai	.	.	Computer.
" S. Sitarama Aiyar, B.A.	.	.	1st Assistant.
" E. Ramanujam Pillai	.	.	2nd "

On the 4th December 1899, M. R. Ry. S. Sitarama Aiyar was transferred to the Kodaikanal Observatory and M. R. Ry. M. B. Subba Rao was appointed in his place. This is the only change that was made in the staff during the year.

3. The work was distributed as follows:—

(a) Computer.—Management of office work, correspondence and star observations.

(b) 1st and 2nd Assistants.—Meteorological observations, reductions and time signals.

4. *Astronomical observations and reductions.*—The observations for the determination of time were carried on as usual. Three hundred and sixty-two observations of stars, 72 of azimuth stars, and 86 determinations of level and collimation were made during the year. Nearly all these observations were made by the Computer M. R. Ry. S. Solomon Pillai.

Watch was kept for the expected November meteors or Leonid shower on five nights from the 13th to 17th November 1899, in which the Deputy Director, the Computer and the 1st Assistant took part. The results were sent to the Director at the Kodaikanal Observatory.

5. *Meteorological Observations.*—The meteorological registers were maintained as in former years. Only two instruments were replaced during the year, *viz.*, the sunshine recorder and the sun radiation thermometer, the former having been removed to Kodaikanal and the mercury column in the latter split up.

By means of the barograph, thermograph and anemograph a complete series of hourly records of pressure, temperature, humidity, wind and rain is made and kept in registers. The traces of the barograph and thermograph are compared with the eye observations of the standard instruments four times a day and the daily means have the necessary corrections applied to them. The corrections to the wet bulb thermograph are very unsteady.

6. *Time Service.*—The time service was maintained as usual. The time-gun at Fort St. George failed on 30 occasions out of 730 giving a percentage of success of 96. The time-ball at the Port Office failed at 1 P.M. on three days when it was correctly dropped at 2 P.M. The 4 P.M. signal was received at the Central Telegraph Office on every day except on the 9th February 1900. The

following table shows all the failures and their causes so far as these could be ascertained :—

Month and date.	Signal.	Fault.	Cause.
1899 April 16	Noon gun	Failed	Tube broke.
" " 28	8 P.M. gun	Do.	Missed fire.
" May 9	Do.	Do.	Do.
" " 10	Do.	Fired before time	Fired by accident by the gunner.
" " 12	Do.	Failed	Bad tube.
" " 17	Time ball	Failed 1 P.M., dropped 2 P.M.	
" " 18	8 P.M. gun	Failed	Tube failed.
" " 30	Do.	Do.	Missed fire.
" " 31	Do.	Do.	Do.
" June 1	Do.	Do.	Tube failed.
" " 29	Do.	Do.	Line broke.
" July 5	Time-ball	Failed 1 P.M., dropped 2 P.M.	No connection. Fault at Telegraph Office.
" " 31	Noon gun	Failed	Tube failed.
" October 15	Do.	Do.	Gunner absent.
" " 22	8 P.M. gun	Do.	Wire broke.
" November 4	Noon gun	Do.	Gunner late.
" " 16	8 P.M. gun	Do.	Unknown.
" December 16	Time-ball	Failed 1 P.M., dropped 2 P.M.	
" " 20	8 P.M. gun	Failed	Wire broke.
" " 27	Noon gun	Do.	Unknown.
" " 31	8 P.M. gun	Do.	Gunner late.
1900 January 16	Do.	Do.	Unknown.
" " 27	Noon gun	Do.	Do.
" February 9	4 P.M. roll	Not received at Telegraph Office	
" " 13	8 P.M. gun	Failed	Do.
" " 15	Do.	Do.	Do.
" " 19	Noon gun	Do.	Do.
" " 28	8 P.M. gun	Do.	Do.
" March 1	Noon gun	Do.	Defect in the earth wire at the Fort.
" " 2	Do.	Do.	Unknown.
" " 3	Do.	Do.	Do.
" " 6	8 P.M. gun	Do.	Do.
" " 28	Do.	Do.	Gunner late.
" " 29	Do.	Do.	Unknown.

The most unsatisfactory feature in the above was the large number of failures of gun (12), the causes of which were not known. On these occasions the lever of the firing machine did not drop and release the weight. A new earth wire was put up at the Fort at the beginning of March. This, though an improvement on the old one, did not mend matters, and there were no less than five failures during the month due to some unknown cause. Finally it was

determined to replace the firing machine by another. This has been done, and the old one has been sent to Arkonam to be repaired.

7. *Daily weather telegrams and special storm observations.*—Daily weather messages have, as usual, been despatched to Simla, Calcutta and Bombay. The meteorological return (10h and 16h obs.) has been supplied to the Meteorological Office, Calcutta.

Special storm observations were supplied to the Meteorological Reporter, Bengal, on four occasions, *vis.*, 24th to 28th October, 20th to 23rd November, 28th to 30th November, and 12th to 13th December 1899.

Observations of the movement of the upper clouds and those of the evaporimeter were continued.

8. *Instruments*—

- (1) Milne's seismograph which has been in use here since May 1898 was removed to Kodaikanal on the 7th December 1899 as suggested in the last year's report.
- (2) The sunshine recorder by Casella No. 131 was also removed to Kodaikanal and replaced by another, Cas. No. 149, received from the Calcutta Meteorological Office on the 19th November 1899.
- (3) The transit clock by Dent was cleaned and a new line to the weight was put in as the old one gave away. The standard chronometer by Victor Kullberg and the thermograph were also cleaned.

The condition of most of the instruments has been satisfactory except the wet bulb thermograph whose corrections are very unsteady.

9. *Repairs.*—Certain repairs to the house and offices that were urgently needed were effected during the year.

10. The following summary of the chief features of the meteorology of the year 1899 was published in the gazette:—

Pressure—Was above the average for June, July, September, October, November, and December and below it for the other months. The mean daily pressure was lowest on the 24th May, 29·573 inches, and highest on the 26th December, 30·132 inches.

Temperature—Was below the average for April, October and December, normal in January and above the average for the other months. The highest shade temperature recorded was 104°·3 F. on the 29th May, and the lowest was 60°·1 F. on 25th January.

Humidity—Was below the average for June, July, August, November and December, normal for January and above the average for the other months. Humidity was lowest on the 19th July, when it was 24.

Rainfall—Was above the average in April, July, September and October and below the average in all other months. The deficiency for the year was 8·02 inches. During October 22·29 inches fell, and the heaviest fall in one day was 2·96 inches on the 23rd of that month. The total fall in November and December was only 1·79 inches.

Wind.—The wind direction was most abnormal during October when it was four points more northerly than usual. This was chiefly due to the presence of a large diffuse depression in the south-west of the Bay which persisted during almost the whole of the latter half of the month. This did not develop into a storm and ultimately broke up about the end of the month. The daily air movement was above normal for February when the direction was also three points

more southerly than usual, normal for July and below normal for all other months.

Sunshine.—The percentage of bright sunshine was above normal in July, November, and December, normal in September, and below normal in the other months. There were 2,566 hours of sunshine during the year out of a total possible of 4,409 hours.

Storms.—None.

MADRAS :
5th May 1900.

R. LLEWELYN JONES,
Deputy Director.

Appendix I.

*Abstract of the mean meteorological conditions of Madras in the year 1899,
compared with the average of past years.*

Mean value of	1899.	Difference from	Average.
Reduced atmospheric pressure	29'876	0'009 above	29'867
Temperature of air	81'7	0'6 do.	81'1
Do. of evaporation	74'6	0'1 do.	74'5
Percentage of humidity	73	1 do.	72
Greatest solar heat in <i>vacuo</i>	147'0	7'3 do.	139'7
Maximum in shade	91'3	0'5 do.	90'8
Minimum in shade	74'6	0'1 below	74'7
Do. on grass	72'4	0'5 above.	71'9
Rain since January 1st on 63 days	41'00	8'02 below	49'02
General direction of wind	S.E.	Same as	S.E.
Daily velocity in miles	152	19 below	171
Percentage of clear sky	55	4 above	51
Do. of bright sunshine	58'2	2'7 below	60'9

Appendix II.

Number of hours of wind from each point in the year 1899.

MONTH.	N	1	2	3	4	5	6	7	E	9	10	11	12	13	14	15	S	17	18	19	20	21	22	23	W	25	26	27	28	29	30	31	Calm.		
January	5	25	33	122	121	78	79	106	67	80	6	2	14
February	3	2	18	50	104	87	24	17	3	52	146	108	15	6	6	20	7	4
March	2	4	45	25	26	73	34	137	202	112	22	6	11	16	10	1	1	2	1	14	
April	...	...	...	1	1	6	3	18	4	18	64	47	101	221	77	25	7	9	23	17	12	18	4	5	2	2	2	2	1	...	...	...	14
May	3	1	1	...	2	...	1	1	5	15	4	15	18	183	110	56	33	44	35	21	16	22	29	34	34	34	9	3	4	3	4	1	...		
June	3	1	...	...	1	...	1	2	1	5	8	14	27	49	46	91	36	37	26	29	33	61	79	50	42	44	19	7	4	2	...	...	
July	7	...	1	1	1	1	4	7	9	12	25	43	51	58	48	42	27	21	22	27	10	33	47	47	48	55	62	21	4	4	2	2	2		
August	2	1	...	2	2	3	3	7	18	18	33	42	32	47	43	52	35	38	20	31	13	38	31	30	47	50	48	30	14	9	...	2	3		
September	5	8	4	...	...	2	2	5	7	35	26	52	15	89	32	11	14	40	14	28	20	24	31	52	30	42	44	49	8	6	5	1	19
October	42	13	20	40	41	27	8	27	26	13	16	36	55	11	32	5	14	10	2	12	3	3	2	25	3	10	4	7	12	33	108	56	28		
November	35	114	138	203	59	47	20	17	20	26	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	9	4	7	11	7
December	17	43	227	184	125	85	36	13	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7
Annual	119	206	424	556	355	269	211	352	275	272	272	288	488	1,006	608	319	178	216	178	182	108	200	235	244	206	237	188	122	56	61	130	86	113		

Appendix III.

Number of miles of wind from each point, in the year 1899.

MONTH.	N	1	2	3	4	5	6	7	E	9	10	11	12	13	14	15	S	17	18	19	20	21	22	23	W	25	26	27	28	29	30	31	Monthly Total.	
January	38	154	186	813	1018	583	402	384	224	340	34	7	4236
February	21	10	79	285	599	379	174	46	17	227	743	672	119	37	47	161	59	3675
March	...	...	...	...	...	6	21	185	147	101	240	277	619	1187	593	143	47	57	96	69	7	9	15	7	...	...	...	...	...	...	...	...	3826
April	...	...	...	10	8	14	22	94	21	112	325	208	586	1667	483	147	51	61	125	126	70	64	69	28	6	17	9	10	7	16	20	...	4376
May	14	9	7	...	28	...	15	12	29	111	42	138	163	1617	754	468	240	313	212	152	100	179	225	260	311	360	70	19	29	24	21	...	5952	
June	27	6	...	...	6	...	7	11	9	27	49	140	231	437	420	727	282	223	197	191	249	475	758	470	413	473	178	51	46	12	...	...	6127
July	29	...	5	6	6	10	36	74	90	110	192	345	415	509	325	270	210	136	129	163	74	228	337	399	503	635	190	20	20	25	15	...	6184	
August	15	9	...	16	18	21	19	65	133	136	223	283	186	305	303	343	227	214	128	170	95	218	219	205	311	383	187	100	65	...	15	...	4982	
September	19	21	13	12	23	51	74	140	118	207	120	557	203	69	83	187	90	111	118	135	150	279	229	299	262	208	34	23	14	3	...	3852
October	184	79	91	268	221	172	53	159	106	48	45	141	189	90	134	34	43	53	8	46	18	13	15	131	22	34	45	68	177	499	266	...	3416	
November	207	530	998	1468	535	283	105	36	64	69	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12	22	20	47	76	...	4412
December	145	289	994	1296	755	568	268	43	32	13	4493
ANNUAL.	678	1097	2294	3778	2605	1748	1256	1713	1308	1368	1314	1763	2736	7112	3887	2320	1220	1291	1146	1087	731	1321	1788	1779	1795	2201	1591	722	326	341	647	478	...	55441

Appendix IV.

Amount of Rainfall from each point during the year 1899.

MONTH.	N	I	2	3	4	5	6	7	E	9	10	11	12	13	14	15	S	17	18	19	20	21	22	23	W	25	26	27	28	29	30	31	Calm.	TOTAL.	
January	0'06	0'06
February
March
April	...	...	...	...	...	0'02	0'01	0'12	...	0'16	0'36	0'56	0'01	0'02	0'86	...	...	...	0'29	...	...	...	...	0'09	...	0'20	0'09	...	...	...	...	...	...	2'79
May	...	...	...	...	...	...	...	...	...	0'03	...	...	...	...	...	0'07	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0'95
June	...	...	...	...	...	...	...	...	...	...	...	...	0'09	...	...	0'05	...	0'06	...	...	0'21	...	...	...	...	...	...	...	...	...	...	...	...	0'52
July	...	...	0'04	...	0'19	...	0'18	...	...	...	0'58	...	...	0'02	...	...	0'02	...	0'05	...	...	0'23	0'06	0'13	0'26	0'01	...	0'23	...	1'94	0'13	...	...	4'14
August	...	...	...	...	...	0'01	...	...	0'13	...	...	0'36	0'05	...	0'02	...	...	...	...	...	0'06	0'20	0'71	...	0'47	0'09	0'40	...	...	...	...	...	...	2'52
September	...	1'01	...	...	...	...	...	...	...	0'16	0'02	0'02	...	...	0'59	0'04	0'04	...	0'31	...	0'12	0'01	...	0'25	...	1'01	1'14	0'62	0'25	0'30	...	0'05	...	5'94
October	1'80	0'48	3'05	0'97	0'35	0'48	0'24	0'84	1'90	...	0'10	...	...	...	...	...	...	...	...	1'04	...	...	0'01	...	0'24	0'04	0'40	0'37	1'71	3'28	4'99	...	...	22'29
November	...	0'05	0'05	0'27	0'13	0'03	0'05	...	0'22	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0'33	0'32	0'05	...	...	1'50
December	...	...	...	0'02	0'02	...	0'17	0'05	0'03	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0'29
ANNUAL	1'91	1'60	3'14	1'26	0'69	0'54	0'65	1'01	2'28	0'35	1'06	0'94	0'15	0'04	1'47	0'16	0'06	...	0'71	...	1'43	0'44	0'77	0'41	0'35	1'73	1'47	1'74	0'62	2'01	6'47	5'44	0'10	41'00	

Appendix V.

MONTH.	WIND RESULTANT.		CLOUDS. (0-10).					BRIGHT SUNSHINE.		AMOUNT OF EVAPORATION.
	Velocity.	Direction.	8h.	10h.	16h.	20h.	Mean	Average per day.	Greatest No. of hrs. in one day.	Average per day.
	Miles.	Points.						Hours.	Hours.	Inches.
January	124	NE by E	4.4	4.8	4.3	3.0	4.1	7.7	9.8	0.154
February	100	SE by E	2.5	3.4	2.1	1.1	2.3	9.4	10.4	.181
March	104	SE by S	2.1	2.1	1.2	0.8	1.6	9.1	10.5	.210
April	119	SE by S	5.1	4.9	3.1	2.7	4.0	8.6	11.3	.230
May	118	South.	4.2	4.2	4.1	2.7	3.8	8.0	10.8	.300
June	126	SW by S	6.1	6.3	7.9	5.4	6.5	4.5	9.5	.301
July	79	SW by S	4.5	4.8	6.2	5.8	5.4	7.1	10.0	.294
August	62	SSW	6.5	6.2	7.5	7.0	6.8	4.6	10.1	.224
September	48	SSW	5.6	5.2	6.1	4.5	5.3	5.4	10.4	.181
October	40	NNE	6.9	7.3	6.1	5.6	6.5	4.8	10.3	.202*
November	137	NE by N	4.2	4.9	4.7	2.9	4.1	7.4	9.7	.176
December	135	NE by N	3.3	4.8	4.3	1.7	3.6	8.0	9.5	.157
ANNUAL	35	SE by S	4.6	4.9	4.8	3.6	4.5	7.1	...	...

* Mean of the 1st 16 days.

Appendix VI.

Mean Monthly and Annual Meteorological Results at the Madras Observatory in 1899.

	BAROMETER.		DRY BULB THERMOMETER.			WET BULB.		TENSION OF VAPOUR.		RELATIVE HUMIDITY.		Sun Max. in Vacuo.		Min. on Grass.		WIND.		RAIN.		Clear sky.	Bright sun shine.	GENERAL WEATHER.
	Reduced to 32°	Daily Range.	Mean.	Max.	Min.	Range.	Mean.	Min.	By Blanford's Tables.		Cents.	Miles.	Points.	Mean Direction.		Amount.	Days.					
									Inch.	Inch.				Points.	Points.							
January	29.993	0.116	75.1	83.8	66.8	17.0	69.3	...	0.643	73	73	137	5	NE by E	0.06	2	59	238.2				
February	.937	.125	77.4	86.1	68.9	17.2	71.7	...	.705	75	75	131	11	SE by E	...	...	77	264.3	
March	.902	.126	80.2	90.5	71.0	19.5	74.8	...	.774	75	75	123	12	SE	...	...	84	282.3	
April	.827	.129	83.5	92.0	77.6	14.4	78.5	...	.907	79	79	146	13	SE by S	2.79	7	60	257.9		
May	.729	.122	87.3	98.7	80.3	18.4	78.9	...	.876	68	68	192	17	S by W	0.95	2	62	249.3		
June	.713	.118	88.1	99.9	81.8	18.1	77.0	...	.778	59	59	204	19	SW by S	0.52	3	35	133.5		
July	.743	.126	86.8	99.4	80.0	19.4	77.6	...	.779	62	62	199	19	SW by S	4.14	8	46	218.7		
August	.736	.124	85.0	95.8	78.8	17.0	77.2	...	.833	69	69	161	18	SSW	2.52	8	32	142.6		
September	.810	.113	83.2	92.9	76.9	16.0	77.3	...	.859	76	76	128	18	SSW	5.94	9	47	161.1		
October	.868	.118	80.1	87.0	74.9	12.1	76.6	...	.870	86	86	110	3	NE by N	22.9	18	35	147.8		
November	.974	.111	78.0	85.7	71.1	14.6	72.9	...	.740	77	77	147	3	NE by N	1.50	4	59	222.1		
December	30.014	.115	75.1	84.2	66.9	17.3	70.0	...	.669	76	76	142	3	NE by N	0.20	2	64	248.1		
ANNUAL	29.854	.120	81.7	91.3	74.6	16.7	75.1	...	.786	73	73	152	12	SE	41.00	63	55	2565.9		

Appendix VII.

Extreme Monthly Meteorological Records at the Madras Observatory in 1899.

	BAROMETER.			DRY BULB THERMOMETER.			HUMIDITY.			SUN TH. IN VACUO.			GRASS THERM.			WIND.			RAIN.	
	Highest.	Lowest.	Range.	Highest.	Lowest.	Range.	Cents.	Day.	Lowest.	Highest.	Day.	Lowest.	Highest.	Day.	Lowest.	Highest.	Miles.	Day.	Inches.	Days.
January	30.106	29.878	0.228	88.2	60.1	28.1	34	7	154.3	56.3	25	27	27	25	21	271	63	7	0.04	...
February	.680	.740	.340	91.5	64.5	27	44	19	152.6	60.1	6	6	6	5	187	71	12	12	...	...
March	.665	.707	.358	98.1	65.6	32	37	14	152.8	61.2	14	11	11	14	179	82	11 & 13	15	...	...
April	.933	.715	.218	101.8	73.9	28	49	27	157.8	72.9	6	13	13	6	197	51	15	15	...	...
May	.918	.573	.345	104.3	73.5	31	31	28 & 29	164.3	74.0	8	28	28	8	246	140	18	18	0.88	16
June	.805	.575	.230	103.5	75.3	28	31	2	165.9	75.1	28	22	22	28	242	161	5	5	1.35	27
July	.875	.580	.295	102.7	71.0	31	24	19	158.7	69.5	31	12	12	31	251	137	31	31	1.17	31
August	.863	.590	.273	100.8	73.2	27	37	7	162.3	72.0	25	18	18	25	225	125	3	3	1.01	25
September	.951	.661	.290	98.7	74.0	24	50	12 & 13	158.4	72.0	26	6	6	25	215	74	5	5	2.03	18
October	30.017	.727	.290	95.4	71.5	24	37	1	159.0	70.9	26	9 & 19	19	26	158	64	28	28	2.96	23
November	.118	.834	.284	88.2	66.5	21	52	17 & 27	151.9	62.7	18	24	24	18	265	55	14	14	0.77	1
December	.132	.922	.210	85.8	62.5	23	55	30	153.2	57.9	27	17	17	27	279	58	31	31	0.27	1

Appendix VIII.

Abnormals from monthly means for the year 1899.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Reduced atmospheric pressure	-0'007	-0'031	-0'006	-0'001	-0'009	+0'007	+0'019	-0'017	+0'030	+0'024	+0'048	+0'033	+0'009
Temperature of air . . .	Same as.	+0'7	+0'2	-0'5	+0'6	+1'7	+2'3	+1'7	+0'2	-0'5	+0'5	-0'4	+0'6
Temperature of evaporation . . .	+0'1	+0'9	+0'9	+0'9	+0'6	+0'4	+0'7	+1'2	+1'0	+1'0	Same as	-0'6	+0'1
Percentage of humidity . . .	Same as.	+2	+1	+5	+1	-3	-3	-1	+4	+8	-2	-1	+1
Greatest solar heat in vacuo . . .	+8'7	+7'5	+6'9	+4'4	+2	+8'6	+10'8	+5'4	+4'3	-4'5	+8'3	+11'7	+7'3
Maximum in shade . . .	-0'8	-0'5	+1'3	-0'9	+0'9	+1'6	+3'8	+2'1	-0'3	-2'0	+0'7	+0'6	+0'5
Minimum in shade . . .	-0'7	+0'9	-1'1	+0'4	-0'5	+1'5	+1'5	+1'5	-0'2	-0'3	-1'2	-2'9	-0'1
Minimum on grass . . .	-0'6	+1'6	-0'8	+1'2	+0'3	+2'2	+2'0	+2'4	+0'8	+0'7	-1'8	-2'9	+0'5
Rain in . . .	-0'83	-0'28	-0'39	+2'17	-1'17	-1'59	+0'27	-2'04	+1'25	+11'29	-11'71	-4'99	...
Rain since January . . .	...	-1'11	-1'50	+0'67	-0'50	-2'09	-1'82	-3'86	-2'61	+8'68	-3'03	-8'02	-8'02
General direction of wind . . .	Same as	3 points S	Same as	Same as	2 points W	Same as	1 point S.	1 point S	Same as	4 points N	1 point E	1 point E	Same as
Daily velocity in miles . . .	-7	+9	-29	-45	-35	-16	+1	-13	-28	-13	-18	-41	-19
Percentage of clear sky . . .	-4	+1	+8	-12	Same as	-1	+17	-1	+9	-6	+18	+16	+4
Percentage of bright sunshine . . .	-8'3	-3'7	-5'3	-7'4	-5'6	-17'6	+22'7	-4'8	-0'3	-15'0	+9'2	+7'1	-2'7

+ Means above normal, - below.