ANNUAL REPORT

OF THE

DIRECTOR

KODAIKANAL AND MADRAS

OBSERVATORIES

FOR 1919

MADRAS:
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1920.

KODAIKANAL AND MADRAS OBSERVATORIES.

REPORT FOR THE YEAR 1919.

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KODAIKANAL AND MADRAS OBSERVATORIES.

I.—REPORT OF THE KODAIKANAL OBSERVATORY FOR THE YEAR 1919.

Staff.—The staff of the Observatory on December 31, 1919, was as follows:—

Director	J. Evershed, F.R.S.
Assistant Director	T. Royds, D.Sc.
First Assistant	A. A. Narayana Ayyar, B.A.
Magnetic Observer	S. S. Ramaswami Ayyangar, B.A.
Second Assistant	Vacant.
Third Assistant	S. Balasundaram Ayyar.
Weather Observer	L. N. Krishnaswami Ayyar.
Writer	S. N. Krishna Ayyar.
Photographic Assistant	R. Krishna Ayyar.
Magnetic Recorder	S. S. Ranga Achariyar.

Dr. Royds was released from his work on deputation to the Director of Ordnance Factories, Calcutta, and rejoined the staff at Kodaikanal on August 4th.

The subordinate staff consists of a book-binder, an assistant book-binder, a mechanic, a temporary assistant mechanic, six peons, a boy peon for the dark room, and two lascars.

2. *Buildings and grounds.*—Some repair work to the roof of the spectroheliograph building was partially carried out by the Department of Public Works but left in an unfinished and very unsightly condition. The wire fencing of the observatory compound is in a very unsatisfactory state and repairs were called for in the year 1916, but the Department of Public Works have not yet put the work in hand.

3. *Instruments.*—The 15-inch lens borrowed from the Nizamiah Observatory, Hyderabad, has been in constant use for solar and Venus spectra. The colour curve of this lens has been determined to facilitate accurate focussing for any region of the spectrum. The 8-inch telescope formerly used as a horizontal telescope at Poona Observatory has been mounted on the equatorial of the 20-inch Poona reflector, but had not been brought into use at the close of the year. All of the instruments in use have been kept in good repair and the 18-inch siderostat mirror was resilvered twice during the year. The operation of removing the mirror from its cell, silvering it, and replacing in the cell now takes about two hours only.

4. *Weather conditions.*—With a total rainfall of 65 inches, well distributed through the year, the conditions generally for astronomical work were extremely bad. The mean definition in the north dome at about 8 a.m. was 3·1 on a scale in which 1 is the worst and 5 the best. There were 42 days in which the definition was estimated as 4 or over.

5. *Photoheliograph.*—Photographs on a scale of 8 inches to the sun's diameter were obtained on 333 days using a 6-inch visual achromatic lens and a green colour screen. This combination gives much better contrast in the details of the solar surface, sunspots, etc., than the photo-visual lens without a colour screen.

6. *Spectroheliographs.*—Monochromatic images of the sun's disc in K light were obtained on 329 days, prominence plates on 248 days and Hα disc plates on 257 days.

7. *Six-inch Cooke equatorial and spectroscope.*—Work with this instrument has been continued on the same lines as formerly for visual observations of solar phenomena which cannot be readily photographed.

8. *Grating spectrograph.*—This instrument was actively employed throughout the year in photographing solar and arc spectra. A continuous series of sunlight and Fe arc spectra was taken to test the constancy of the Sun—arc displacement. Confining attention to the region 4337–4531 and to lines that are not subject to pole effect in the arc, it was found that some remarkable variations occurred amounting to several thousandths of an angstrom. The variations are of two kinds; a general change affecting all the lines in the region studied, and a change affecting particular lines or groups of lines. In the latter case measures of the distances separating the iron lines in the Sun, and similar measures of the iron lines in the arc, show that the variations are generally due to a slight instability of wave-length in the arc lines. In a few cases there is evidence that the solar lines are not absolutely fixed in their relative positions in the spectrum. Photographs of the iron arc under various conditions also indicate small changes of wave-length, particularly in some plates taken for the purpose of estimating the displacements of lines sensitive to pole effect.

Experiments designed to indicate the cause of these anomalies have all given negative results. It is thought that they may possibly be due to changes in the composition of the samples of impure iron and steel used as pole pieces; or they may have significance in relation to the recent discovery that many elements consist of two or more isotopes, and that differences of wave length of the same order are found in the spectra of the isotopes of lead.

The research is a difficult one being concerned with very small quantities; it is only rendered practicable by the method of superposing a reversed positive on a negative of the spectrum, whereby the displacements are revealed with certainty and estimated rapidly.

9. *Displacements of lines and Einstein's prediction.*—Measures have been made by Mr. Narayana Ayyar of the displacements at the sun's polar limbs of the nitrogen bands near 3883. Fifteen plates of limb spectra and carbon arc, and 10 plates of spectra at the centre of the disc, give the following mean displacements of ten prominent triplet bands :—

	In angstroms.	In Km/sec.
North limb	+ 0·0061	+ 0·47
South limb	+ 0·0088	+ 0·68
Centre of disc	+ 0·0043	+ 0·33

These values are very much larger than were obtained by St. John for other groups of lines in the carbon arc spectrum, and taken by themselves they appear favourable to Einstein's theory. The systematic difference between north and south indicates that the displacement may be variable.

Measures of limb spectra in high latitudes and with iron arc comparison also show the difference between north and south, although these were photographed a year later than the carbon arc spectra. The results of this series of plates, taking the mean of ten lines, is as follows :—

	In angstroms.	In Km/sec.
North limb	+ 0·0099	+ 0·67
South limb	+ 0·0134	+ 0·91
Centre of disc	+ 0·0070	+ 0·47

All of these results are free from pole effect in the arc and from pressure shift. Our previous researches having shown that pressure does not affect the displacements of the iron lines in the Sun our results for these lines should be considered to be as important a test of the relativity theory as the measures of the nitrogen band lines.

The general result that both band lines and iron lines are displaced at the limb by amounts that, if not in exact agreement with the predicted amount, are of the right sign and order of magnitude appears favourable to Einstein's hypothesis. But the displacement differs for different substances and for different lines in the same substance ; and previous work has shown that there is no proportionality between displacement and wave-length. If the displacements are due to a gravitational effect therefore, there must be an unknown modifying influence at work.

The measures of Venus spectra offer the most serious difficulty, for they appear to show that the line displacement only occurs in the light derived from the hemisphere of the Sun facing the Earth.

The hypothesis that motion in the line of sight is the only cause of the line displacement has this great advantage, that all of the anomalies mentioned, including the Venus results, are readily explained. But it involves a controlling action by the Earth which is very difficult to believe.

10. *Venus spectra.*—Between February and June twenty-one measurable plates of Venus and Fe arc were obtained, and ten ordinary daylight control plates. The planet during this period was an evening star and this circumstance gave rise to a serious and unexpected difficulty, for on clear afternoons the heating of a wall by the Sun set up a strain in the masonry of the pier carrying the grating, and after sunset a slight movement of recovery. It is believed that this made the grating rotate through an angle of about 1″ during the exposures on Venus causing a slight drift of the spectra and a broadening of the lines. As this broadening would act unequally on the bright lines of the arc and the absorption lines of Venus measures of the displacements are considered to give very unreliable results.

The cause of the trouble was not discovered and rectified until the middle of April when the wall was completely cut away from all connexion with pier. The February and March plates which should have given decisive results with regard to the wave-length of the lines on the hidden face of the Sun are unfortunately all affected by this source of error. The mean results, Sun—arc, of the plates measured are given in the following table in angstroms :—

		Mean angle ♀—⊙—⊕	More affected lines.	Less affected lines.
10 control plates of daylight		——	+0·0103	+0·0036
4 Venus plates in February	...	129°	+0·0163	+0·0096
7 „ „ March	..	113°	+0·0097	−0·0000
5 „ „ April	...	102°	+0·0065	−0·0033
5 „ „ May and June	...	67°	+0·0083	+0·0007

The anomalous result for the February plates and the relatively high values of the March plates are probably due to the movement of the grating. The April, May and June plates which are free from this defect give values of Sun—arc in accordance with the excellent series obtained in 1918 and referred to in the last Annual Report. They show smaller shifts than the control plates and a tendency to increase as the angle at the Sun diminishes.

A set of eight plates was obtained in November with the planet near western elongation, and the series will be continued until April 1920 when it is hoped that a decisive result may be reached.

11. *Rotation of Venus.*—An inclination of 1° to 2° in the lines of the Venus spectra was found in many of the plates, and this would appear to indicate a direct rotation of the planet in a period of between 20 and 30 hours. Further investigation shows however that this interpretation is not justified. It is probable that a spurious inclination may be produced when the diurnal movement is inclined to the spectrograph slit and irregularities in guiding are mainly in the direction of Right Ascension ; for in this case there will be a partial illumination of the slit on one side or

the other according as the image is above or below its mean position on the slit, and this will cause opposite displacements at the two edges of the spectrum. Owing to this uncertainty nothing can yet be said regarding the true rotation period of the planet.

12. *Irregular displacements of spectrum lines on the disc of the Sun.*—Photographs of sections of the Sun's disc have been made in the Hα region, and the region studied in the Sun and Fe arc plates. It was found that the irregular displacements discovered in 1918 by superposing a reversed positive on a negative of the spectrum may be observed at the centre of the disc, but up to the present they have not been found very near the limb. It appears therefore that, unlike the displacements in the penumbrae of spots, they may be due to movements normal to the surface, or having a component normal to the surface.

Summary of sunspot and prominence observations.

13. *Sunspots.*—The following table shows the monthly numbers of new groups observed at Kodaikanal, and their distribution between the northern and southern hemispheres. The mean daily numbers of spots visible are also given :—

—	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
New groups	24	16	23	18	16	32	18	19	18	16	12	23	235
North	11	11	14	8	7	13	7	2	5	7	8	11	104
South	13	5	9	10	9	19	11	17	13	9	4	12	131
Daily numbers ...	3·5	4·2	4·4	3·5	4·7	6·4	4·0	4·3	3·8	3·9	2·7	3·2	4·1

Compared with the year 1918 there is a general decrease in spot activity amounting to 29 per cent in the case of new groups. The decrease is much greater for the northern hemisphere than for the southern and there results a considerable preponderance of activity in the south.

The approximate mean latitude of the spots was 10°·4 in the northern and 12°·5 in the southern hemispheres ; a decline of 1°·4 and 2°·1 respectively compared with the figures for 1918.

A remarkable spot group was formed about August 12 on the east limb, on the 14th displacements of the brightly reversed Hα line ranging from 6 A towards red to 5 A towards violet were observed at various points in the group. During the September apparition the group had become resolved into two large single spots very near together but on opposite sides of the equator.

The number of bright reversals of the Hα line observed in the neighbourhood of spots was 296 whilst the number of displacements of this line recorded near spots was 180 of which no less than 136 were towards red. There were 57 dark reversals of D_3 observed.

14. *Prominences.*—There has been a slight decrease in prominence areas and a considerable reduction in numbers compared with the previous year. The mean daily areas derived from the Kodaikanal photographic records are as follows :—

	North.	South.	Total.
1919—January to June	1·55	1·81	3·36
July to December	1·96	2·09	4·05

The mean daily numbers recorded decreased from 13·6 for the first half of 1919 to 11·3 for the second half ; the decrease is mainly in the number of small prominences.

Prominence activity has been considerable in the equatorial regions and as far as latitude 40° ; beyond this latitude a rapid decrease is shown, and at 60° the activity practically ceases. Between 60° and the poles very small prominences or transient jets were recorded.

Metallic prominences greatly increased in frequency compared with the year 1918 and prominences showing displaced lines were also more frequently recorded than in the previous year. No displacement exceeding 6 angstroms at Hα was seen. There was the usual slight excess of displacements towards red, 54 per cent of the whole number showing motion away from the Earth.

Prominences projected on the disc as absorption markings gave the same latitude distribution as those observed at the limb. The mean areas are about 3 per cent, and numbers 17 per cent less than in 1918 ; the decrease is therefore mainly in the number of smaller markings as in the prominences at the limb.

The largest prominence photographed during the year attained its greatest development of 12 square minutes of arc on May 29 when a great part of it became detached from the Sun and ascended into space. The angular rotation speed of the prominence, when visible as an absorption marking between May 7th and 13th, was found to be 14°·28 per diem, in agreement with the rotation speed of the reversing layer.

15. *Magnetic observations.*—Continuous magnetograph records are obtained of declination, vertical force, and horizontal force. Absolute observations for dip are made daily excepting Sundays, declination and horizontal force on three days per week alternately. All the records are made over to the Magnetic Survey office, Dehra Dun, and the results are published by the Survey annually.

The declination magnetograph was cleaned early in the year but owing to the excessive dampness of the magnetograph room it is very difficult to keep in good working order and it has been necessary to readjust it several times. The earth inductor No. 45 hitherto in use was sent to the Survey Department for repairs and has been replaced by No. 46 which has proved a less satisfactory instrument.

Twenty-six "great" and 176 "moderate" magnetic storms were registered during the year, a larger number of each designation than were recorded in 1918.

The storm commencing August 11, $12^h\ 28^m$ I.S.T. ($6^h\ 58^m$ G.C.T.) was perhaps the greatest storm recorded since 1909 September 25. A large and very active spot group was developing at the east limb on the 12th.

16. *Workshop construction.*—New iron mountings were made for the large collimator and camera lenses of the 6-inch grating spectrograph. These heavy parts were permanently fixed on the masonry pier by embedding them in asphalt. The collimator is provided with a focussing screw of 1 mm pitch and the camera mounting has a rack and pinion for focussing. The grating mounting was also improved and an iron cup containing mercury attached to it. The bulb of a very sensitive thermometer is immersed in the mercury.

The 6-inch Cooke equatorial telescope was repaired and re-erected. The heavy cast iron sleeve of the declination axis had been broken across near the end on the journey from Kashmir. A satisfactory repair was effected by turning down the broken end to an even cylindrical surface and shrinking a length of steel tube on to it. This was then attached by screws to the larger portion of the broken sleeve.

The old Shelton clock used in the spectroheliograph room for timing all photographs caused much trouble by repeated stoppages. As matters

were not improved by most careful cleaning and oiling, the expedient was tried which had proved so very effective for the driving clock of the large siderostat and for other driving clocks ; this consists in adding one wheel to the clock of slightly larger diameter than the winding drum. The wheel was placed above the clock train and the end of the driving cord, usually attached to a fixed support, is attached instead to the middle of the winding drum and carried over the wheel and down to the weight pulley where it is made continuous with the cord passing directly down from the drum. In this way the driving force of the weight is doubled and it falls at twice its former speed. The advantage gained consists in the reduction of friction at the drum axis due to the balanced pull on the drum. The mass of the weight might be halved or greatly reduced and it would seem that this would be necessary to prevent the weight from unduly controlling the pendulum. However, since this arrangement was added no stoppages have occurred and the clock rate has proved so remarkably uniform that no change in the weight has been made.

This clock is at least 130 years old. It was installed at the Madras Observatory at the foundation of that institution in the year 1791. It has given excellent service throughout its long career, and it is hoped may continue to give accurate time for a further long period.

17. *Madras Observatory.*—The transit instrument and the 8-inch Equatorial telescope were cleaned and completely overhauled in December, and the dome of the Equatorial was made to rotate satisfactorily by removing one of the supporting wheels ; this was in order to put more weight on the driving wheel and give it some resilience. This method had been found quite successful in the case of another troublesome dome at Kodaikanal. Tests of the solar definition and the definition of stars in daylight were made with the 8-inch. As in previous trials the seeing was found to be extraordinarily good near midday and it is considered that these observations have, with others, demonstrated the immense advantage for solar work of the proximity of the sea or other extended water surface.

18. *Time.*—The error of the standard clock is usually determined by reference to the 16-hour signal from the Madras Observatory. This is rendered possible by the courtesy of the Telegraph Department which permits the Madras wire to be joined through to this observatory. The signal is received with accuracy on most days and all failures are at once reported to the Postmaster-General, Madras.

19. *Meteorology.*—Eye observations are made at 8^h, 10^h and 16^h local mean time as in former years. The Richard thermograph (wet and dry bulb) and barograph, the Beckley anemograph, and the sunshine recorder also continue in use. Cloud observations with the nephoscope are made three times daily.

Pressure.—The average pressure for the year was 0·006 inch above normal. The mean pressure was above normal from January to April and August to October and below normal in the remaining months, the greatest excess being 0·029 inch in February and the greatest defect 0·038 in November. The highest pressure recorded was 22·972 inches on February 5 and the lowest 22·643 inches on July 30.

Temperature.—The monthly mean temperature was above normal in every month, the mean for the year being 2° in excess. The minimum grass temperature for the year was 27°·1 on January 17.

Humidity.—The mean humidity for the year was normal, viz., 74 cents. The driest day in the year was March 10, when the humidity was 7 cents.

Rainfall.—The total annual fall was 65 inches or 5·5 inches above normal. The wettest month was September when 11·68 inches fell on 17 days and the driest was February with 0·33 inches on one day only.

Wind.—The wind direction was not far from normal in all months except May when the mean was S. by W. instead of N.N.E. The mean daily movement was 268 miles, the normal being 306 miles. The mean velocity was in defect in all months except June.

Transparency of the atmosphere.—The transparency of the lower atmosphere as judged by the visibility of the Nilgiris, about 100 miles distant, was very near the average.

Cloud and sunshine.—The percentage of cloud was normal in January and October, below normal in February and March and above normal in the remaining months. July and September were the cloudiest months. The total number of hours of bright sunshine was 2365 which is 17 per cent above normal.

20. *Seismology.*—The Milne horizontal pendulum recorded ninety earthquakes as against 127 during last year. Details of the records are given in Appendix 1.

21. *Library.*—One hundred and seven volumes were bound during the year.

22. *Publications.*—Bulletin Nos. 60 and 61 dealing with the half-yearly distribution of the prominences were issued during the year but only a limited number of copies were distributed outside India.

In addition the Director has contributed a paper on "The Spectrum of Nova Aquilae" to the "Monthly Notices of the Royal Astronomical Society", Vol. 59, page 468 ; and notes on the following subjects to the "Observatory" :—

	Vol.	page.
1. The displacements of the solar lines reflected by Venus	42	51
2. Calcium clouds in the milky way	42	85
3. The Pulsation theory of Cepheid Variables	42	124
4. The Moon in Daylight	42	339

23. *General.*—The staff of the observatory has worked well during the year. Mr. Narayana Ayyar has obtained very satisfactory results in the exacting work of measuring innumerable Sun and arc spectra by the positive on negative method, and Mr. Krishna Ayyar has shown great energy and perseverance in the numerous photographic processes now required, especially in the sensitizing of plates for the Hα spectro-heliograms.

KODAIKANAL,
29th January 1920.

J. EVERSHED,
Director, Kodaikanal and Madras Observatories.

II.—REPORT OF THE MADRAS OBSERVATORY FOR THE YEAR 1919.

Staff.—The following was the staff of the Madras Observatory during the year 1919 :—

Deputy Director	R. Ll. Jones (January 1 to April 4). James Angus (April 5 to May 3). S. Solomon Pillai (May 4 to June 30). Edward B. Ross (July 1 to December 17). Edward Barnes (December 18 to 31).
Computer	S. Solomon Pillai.
First Assistant	C. Chengalvaraya Mudaliyar.
Second Assistant	P. Jayaram Mudaliyar.

Mr. R. Ll. Jones left Madras on combined leave preparatory to retirement. Mr. Solomon Pillai was absent on privilege leave from 1st to 31st October 1919.

2. *Time service.*—The time gun at Fort St. George failed on 11 occasions out of 731 giving a percentage of success of 98·5. Of these failures one was due to a fault at the Observatory. The gun was fired at 8 a.m. and 11 a.m. instead of at 12 noon on November 11 on account of the anniversary of the armistice. The time ball at the Harbour failed altogether on one day. On four other days it failed at 1 p.m. but dropped correctly at 2 p.m. The 4 p.m. roll of signals was sent to the Central Telegraph office on every day and was received there correctly.

3. *Meteorological observations.*—Eye observations were made four times a day and the record of self-registering instruments maintained as usual. Extra observations were taken for storm warning purposes and telegrams sent to Calcutta on 51 occasions and to Simla on one occasion.

4. *Buildings.*—The usual annual repairs to the office and quarters were carried out during the year.

5. *Instruments.*—The following is a list of the instruments at the Observatory on 31st December 1919 :—

(*a*) *Astronomical.*

Eight-inch Equatorial Telescope—Troughton and Simms.
Sidereal clock—Haswall.
Do. Dent, No. 1408.
Do. S. Riefler, No. 61.
Mean Time clock—J. H. Agar Baugh, No. 105.
Do. with galvanometer—Shepherd & Sons.
Meridian circle—Troughton and Simms.
Portable transit instrument—Dollond.
Tape chronograph—R. Fuess.
Relay for use with the chronograph—Siemens.

(*b*) *Meteorological.*

Richard's barograph—No. 10, L. Casella.
Do. thermograph—No. 29637, L. Casella.
Peander's self-recording rain-gauge—No. 116, Lawrence and Mayo.
Beckley's anemograph—Adie.
Sunshine recorder—No. 149, L. Casella.
Nephoscope—Mons Jules Daboseq and Ph. Pellin.
Barometer, Fortin's—No. 1771, L. Casella.
Do. do. No. 725, L. Casella (spare).
Do. do. No. 1420, L. Casella (spare).
Dry bulb thermometer—No. 94221, L. Casella.
Do. do. No. 38037, Negretti and Zambra (spare).

Wet bulb thermometer—No. 94219, L. Casella.
Do. do. No. 38037, Negretti and Zambra (spare).
Dry maximum thermometer—No. 8581, Negretti and Zambra.
Dry minimum do. No. 69017, L. Casella.
Wet do. do. No. 91753, Negretti and Zambra.
Sun maximum do. No. 127618, Negretti and Zambra.
Grass minimum do. No. 3377, Negretti and Zambra.
Rain-gauge (8″ diameter)—No. 1042, Negretti and Zambra.
Measure glass for above.
Rain-gauge (5″ diameter).
Measure glass for above.
Stop watch—No. A-3.

The level error of the Transit Circle at the beginning of the year was + 0^{s}·13. Very little change occurred in the first two months. In the middle of March it began to change in the usual manner and reached its maximum negative value — 4^{s}·31 in the middle of October. In the course of a few days of heavy rain at the beginning of November it went through a rapid change in the reverse direction.

6. *Weather summary.*—The following is a summary of the meteorological conditions at Madras during 1919 :—

Pressure.—The mean monthly pressure was normal in January, April and August, was below normal in June, November and December and above in the remaining months, the greatest excess being 0·075 inch in July and the greatest defect 0·065 inch in November. The highest pressure recorded was 30·130 inches on the 6th and 15th January.

Temperature.—The mean temperature of the air was normal in July and September and above normal during the remaining months. The maximum shade temperature was below normal in July and September, normal in March, October and December and above normal during the other months. The highest temperature recorded was 108°·2 F. on May 21. The minimum in shade was above normal in all other months except September when it was below normal and in March, October and December when it was about normal. The lowest temperature recorded was 64°·5 F. on January 2. The highest sun maximum was 164°·5 F. on September 12, and the lowest on grass 61°·2 F. on January 2.

Humidity.—The percentage of humidity was normal in March, below normal in May, June and August and above during the remaining months. The driest day in the year was June 8.

Wind.—The wind velocity was in defect throughout the year. The wind direction was normal from March to May and in December.

Cloud.—The amount of cloud was above normal in February, June, November and December. The sky was less cloudy than usual during the other months.

Sunshine.—The percentage of sunshine was above normal in July and September and below in all the other months. The total number of hours of bright sunshine during the year was 2206·3.

Rainfall.—The rainfall was above the average in March, June, July, September and December and below in the remaining months. The greatest excess was 2·29 inches in July and the greatest deficiency 2·09 inches in May. The total fall for the year was 50·78 inches on 90 days against an average of 49·02 inches. The monsoon rainfall from October 15 to the end of the year was 27·24 inches. The heaviest rainfall on one day was 3·18 inches on September 28.

THE OBSERVATORY, MADRAS,
31*st January* 1920.

EDWARD BARNES,
Offg. Deputy Director, Madras Observatory.

APPENDIX I.

STATION—KODAIKANAL OBSERVATORY.

SEISMIC RECORDS.

$\phi = 10° 13' 50''$ $\lambda = 77° 28' 00''$ $h = 2343$ metres. *Subsoil*—Rock.

Apparatus—Milne's Horizontal Pendulum Seismograph.

1919.	T_o	$\frac{\tau}{T_o^2}$	1919.	T_o	$\frac{\tau}{T_o^2}$
January	17·3	2·9	July	18·0	2·7
February	17·4	3·0	August	18·0	2·7
March	17·5	3·0	September	17·8	2·8
April	17·6	2·6	October	17·7	2·8
May	17·6	2·8	November	17·9	2·6
June	17·6	2·6	December	18·0	2·6

No.	Date.	Phase.	Time G.M.T.	Period. (Sec.).	Amplitude (u).			Distance Δ (Km.).	Remarks.
					An.	Ae.	Az.		
1	1919. January 1 ...	eP	H. M. S. 1 42 18	...	...	...	...	...	There was another maximum (amplitude 2·0 mm) at 3h 23m·8 and a fresh series of comparatively large oscillations commenced then and lasted for about an hour.
		iL	1 49 30	...	...	.	...	...	
		M	1 50 00	...	...	220	...	...	
		F	5 47 24	...	...	...	...	...	
2	6 ...	eP	22 47 24	...	..	.	. .	...	
		eL	23 20 18	...	...	...	...	...	
		M	23 28 00	...	...	60	.	..	
		F	23 39 42	...		...	..	...	
3	18 ...	eP	6 03 18	...	. .	...	..	...	
		eL	6 08 30	..	...	.	...	...	
		M	6 09 30	. .	...	240	...	...	
		F	6 28 42	...	...	...	..	...	
4	February 12 ...	eP	13 26 24	.	...	..		...	Widening of line.
		F	13 43 48	...	...		...	...	
5	17 ...	eP	18 30 30	...	..	..	...	...	Widening of line.
		F	18 41 18	...	...		...	...	
6	18 ...	eP	16 39 06	...	...	...	.	..	Widening of line.
		F	16 42 30	..	...	...	...	...	
7	22 ..	eP	5 04 54	...	...	...	...	...	Widening of line.
		F	5 10 00	...	..		. .	...	
8	March 2 ...	eP	4 41 48	..	...	...	...	...	
		eL	4 44 18	.	..		...		
		M	4 59 42	...	...	100	...	..	
		F	5 45 18	...	.	...	...	...	
9	2 ...	eP	12 07 24		...	..	...	...	Several widenings of line.
		F	12 58 42	...	...	.	...	...	
10	2 ...	eP	13 00 42	...	...	...	...	...	
		eL	13 08 12	...	...	...	...	...	
		M	13 16 06	...	...	70	...	...	
		F	13 58 42	..	...	.	...	...	
11	9 ...	eP	3 57 54	...	...	.	...	...	
		eL	4 34 12	...	...	...	...	...	
		M	4 50 30	.	..	100	...		
		F	5 05 48	...	...	...	...	...	Record faint as light was burning low. Light was put out at 5h 9m for marking the time on the sheet.
12	16 ..	eP	7 48 24	...	...	..	...	...	
		eL	7 52 12	...	...	...	...	...	
		M	8 08 12	...	...	60	...	...	
		F	8 24 18	...	...	...	...	...	

No.	Date.	Phase.	Time G.M.T. H.	M.	S.	Period. (Sec.).	Amplitude (μ). An.	Ae.	Az	Distance Δ (Km.).	Remarks.
	1919.										
13	March 21 ...	eP	18	07	12	...	...	...	...	...	Widening of line.
		F	18	11	54	...	...	..	...	...	
14	April 2 ...	eP	0	41	42	...		...	...	...	
		eL	0	45	54	...	...	...	...	..	
		M	0	54	54	.	...	180	...	...	
		F	1	10	12	...	...	...	...		
15	7 ...	eP	10	10	00	...	...	...	...	...	Widening of line.
		F	10	12	06	...	...	...	...	...	
16	10 ...	eP	3	39	12	...	...	...	...	...	Widening of line.
		F	3	41	48	...	...	..	...	...	
17	16 ...	P		...		...	...	..	...	...	No P.Ts. Light was removed from 3h 59m to 4h 3m for changing sheet. P.Ts. probably occurred during this interval.
		eL	4	13	48	..	...	.	...	...	
		M	4	15	54	...	...	70	...	...	
		F	4	23	06	...	...	...	...	...	
18	16 ...	eP	17	13	48	...	...	...	...	...	Widening of line.
		F	17	17	42	..	...	...	...	...	
19	17 ...	eP	11	40	48	...	...	...	...	...	
		eL	12	14	06	...	...	..	...	...	
		M	12	32	12	...	...	650	...	...	
		F	13	59	42	...	..	...	...	...	
20	17 ...	eP	21	32	00	...	...	...	...	...	
		eL	22	23	30	...	...	..	...	...	
		M	22	31	36	...	...	80	...	...	
		F	23	14	06	...	...	...	...	...	
21	21 ...	eP	12	21	06	..	...	...	...	...	
		iL	12	28	48	..	...	...	...	...	
		M	12	35	00	...	...	110	...	...	
		F	12	54	36	...	...	...	...	...	
22	23 ...	eP	8	08	36	...	...	...	...	..	Widening of line.
		F	8	20	00	..	..	...	.	...	
23	24 ...	eP	17	29	00	...	...	...	...	...	Widening of line.
		F	17	37	42	...	...	...	...	...	
24	27 ...	eP	0	36	12	...	...	...	...	...	
		eL	0	48	06	...	...	...	..	...	
		M	0	50	24	...	...	110	...	...	
		F	1	16	00	...	...	...	...	...	
25	30 ...	eP	7	36	54	...	...	...	...	...	
		eL	7	43	00	...	...	...	...	...	
		M_1	8	22	48	...	...	1400	...	...	
		M_2	8	26	54	...	...	1550	...	...	
		M_3	8	31	48		...	1480	...	...	
		M_4	8	34	36	...	...	1450		...	
		M_5	8	38	42	.	..	1470	...	...	
		M_6	8	46	24	...	...	1350	...	...	
		M_7	8	49	30	..	..	1300	...	...	
		M_8	8	53	36	..	...	1250	...	...	
		F	12	09	00	...	...	...	...	...	
26	May 1 ...	eP	4	06	24	...	...	...	...	...	Widening of line.
		F	4	08	00	...	...	...	...	...	
27	1 ...	eP	5	21	00	...	...	...	...	...	
		eL	5	29	12	...	...		...	...	
		M	5	33	18	...	...	220	...	...	
		F	6	09	30	..	...		..	...	
28	2 ...	eP	3	07	48	...	...	...	...	...	
		eL	3	14	18	...	...	.	...	...	
		M	3	17	24	...	...	50	...	...	
		F	4	13	00 ?	...	...	..	...	...	Instrument examined at 4h 13m.
29	6 ...	eP	6	31	18	...	...	...	...	...	Widening of line.
		F	6	33	18	.	...	..	...	...	In continuation of hour mark.
30	6 ...	eP	19	30	12	...	...	..	...	...	P.T. merged in hour mark.
		eL	19	55	06	..	....		...	...	
		M	20	28	30	...	...	450	...	...	
		F	23	17	24	...	...	...	...	...	
31	7 ...	eP	5	44	24	...	.	...	..	...	
		eL	6	02	48	...	...	..	...	...	
		M	6	07	12	...	...	50	...	...	
		F	6	24	24	...	...	...	..	...	
32	11 ...	eP	5	35	24		...	...	...	...	Widening of line.
		F	5	38	42	...	...	...	...	...	

No.	Date.	Phase.	Time G.M.T.	Period. (Sec.).	Amplitude (u).			Distance. Δ (Km.)	Remarks.
					An.	Ae.	Az.		
	1919.		H. M. S.						
33	May 22 ...	eP	12 46 18	...	...	...	...	...	Widening of line.
		F	13 06 48	..	..	...	.	...	
34	23 ...	P	...	...	...	...	...	...	No P.Ts.
		iL	6 21 18	...	...	...	..	...	
		M	6 25 36	...	...	200	...	...	
		F	6 55 48	...	...	...	...	...	
35	27 ...	eP	18 15 36	...	...	...	...	...	Widening of line.
		F	18 24 54	...	...	...	...	...	
36	29 ...	eP	11 11 54	...	...	...	...	...	
		eL	11 19 00	...	...	...	...	...	
		M	11 24 36	...	...	50	...	...	
		F	11 34 06	...	...	...		...	
37	June 1 ..	eP	7 05 48	...	...	...	...	...	
		eL	7 07 18	...		...	...	..	
		M	7 08 18	...	...	50	...	...	
		F	7 16 30	...	...	...	...	...	
38	1 ...	eP	15 06 12	...	...	...	...	...	Widening of line.
		F	15 07 48	...	...	...	...	...	
39	7 ...	eP	14 19 12	...	...	...	...	...	Widening of line.
		F	14 20 42	...		...	..	...	
40	7 ...	eP	14 59 06	...	...	..	..	...	Widening of line.
		F	15 00 24	...	...	..	...	...	
41	7 ...	i	15 08 00	...	...	30	...	...	Earthquake of intensity IV heard and felt. Line displaced towards east.
42	10 ...	eP	21 14 24	...	...	..	...	...	Widening of line.
		F	21 16 24	...	...	...	...	...	
43	13 ...	eP	12 20 48	...	...	..	...	...	Widening of line.
		F	12 23 48	...	...	...	...	...	
44	13 ...	eP	18 48 30	...	...	...	..	...	Widening of line.
		F	18 51 12	...	...	...	...	...	
45	20 ...	eP	14 02 48		...	...	...	...	Widening of line.
		F	14 04 00	...	...	..	...	...	
46	20 ...	eP	17 40 12	...	...	...	...	...	Widening of line.
		F	17 41 42	...	...	...	...	...	
47	20 ...	eP	18 17 12	...	.	...	...	...	Widening of line.
		F	18 19 00	...	...	...	...	..	
48	26 ...	eP	17 39 54	...	...	...	...	...	Widening of line.
		F	17 46 48	...	...	...	...	...	
49	28 ...	eP	5 13 54	...	...	...	..	...	
		eL	5 15 54	...	...	. .	...	...	
		M	5 18 00	...	...	30	...	...	
		F	5 27 42	...	. .	...	...	...	
50	28 ...	eP	10 44 48	...	...	...	...	...	Widening of line.
		F	10 46 18	...	...	...	..	...	
51	30 ...	eP	0 43 48	...	...	...	...	...	
		eL	0 54 36	...	...	...	...	...	
		M	0 56 42	...	...	50	...	...	
		F	1 17 12	...	.	...	...	...	
52	30 ...	eP	5 53 48	...	...	..	...	...	Widening of line.
		F	5 55 42	...	...	...	...	...	
53	30 ...	eP	7 40 48	...	...	...	..	...	
		eL	7 47 54	...	...	...	...	...	
		M	7 52 36	..	...	450	...	...	
		F	8 20 18	...	...	...	...	...	Air tremors during high wind were frequent during the month.
54	July 4 ...	eP	13 01 24	...	.	...	...	...	Widening of line.
		F	13 03 36	...	...	...	..	...	
55	4 ..	eP	13 51 36	...	...	...	...	...	
		eL	13 52 54	...	...	...	...	...	
		M	13 55 48	...	...	100	...	...	
		F	14 03 00	...	..	...	...	...	
56	8 ...	eP	21 14 36	...	...	...	...	...	
		iL	21 29 00		...	.	..	...	
		M	21 34 06	...	...	1000	...	...	
		F	?	..	...	...	..	...	The boom touched the box at 21h 36m·7 and did not oscillate afterwards. Hence the end is not recorded.
57	14 ...	eP	14 36 12	...	...	...	...	...	
		eL	14 39 18	...	...		...	...	
		M	14 40 18	...	...	50		...	
		F	14 51 06	...	..	...	...	...	

No.	Date.	Phase.	Time G.M.T. H.	M.	S.	Period. (Sec.).	Amplitude (u). An.	Ae.	Az.	Distance △ (Km.).	Remarks.
	1919.										
58	July 24 ...	eP	2	14	18	...	...	...	.	...	
		iL	2	18	24	...	...	.	...	...	
		M	2	19	24	...	...	680	...	...	
		F		?		...	...	..	...	...	Instrument examined at 2h 45m. Air tremors due to high wind (35 miles an hour) were frequently recorded from 27th to 31st.
59	August 3 ..	eP	3	32	30	...	...	.	...	...	Widening of line.
		F	3	36	06		..		...	...	
60	14 ...	eP	17	46	24	...	..	...	...	..	* Widening of line.
		F	17	53	06		..	...	...	...	
61	25 ...	eP	20	17	00	..	...	..	...	...	Widening of line.
		F	20	21	36	...	...	...	...	...	
62	27 ...	eP	5	58	42	...	...		...	...	Widening of line.
		F	6	14	06	...	..	...	...	...	
63	28 ...	eP	20	02	48	...	...	.		...	Widening of line.
		F	20	07	24	...	. .	...	...	...	
64	29 ...	eP	5	55	30	...	...	...	...	...	
		eL	6	11	18	...	...	...	...	...	
		M	6	18	30	...	...	320	...	...	
		F	7	25	24	..	...	...	..	...	
65	29 ...	eP	8	40	42	...	...	..	...	...	Widening of line.
		F	8	42	48	...	...	...	...	...	
66	31 ...	eP	17	38	12	.	...	...	...	...	
		iL	17	44	06	...	...	...	...	...	
		M_1	17	47	54	...	...	230	. .	...	
		M_2	18	22	36	...	...	180	..	.	
		F	18	55	36	...	...	..	...	...	
67	September 1 ...	eP	20	34	36	...	...	..	...	...	Widening of line.
		F	20	37	06	...	...	...	...	...	
68	12 ..	eP	7	03	18	..	...	...	..	...	
		eL	7	11	36	...	...	...	...	...	
		M	7	14	06	...	...	40	...	...	
		F	7	19	12	...	...	...	...	...	
69	13 ...	P		.		...	...	...	...	...	No P.Ts.
		iL	12	50	42	...	...	..	...	...	
		M	12	51	00	...	...	50	...	...	
		F	13	06	24	...	...	...	...	.	
70	13 ...	eP	13	42	18	...	...	...	...	...	
		eL	13	43	48	...	...	...	...	...	
		M	13	47	24	...	...	60	...	...	
		F	14	02	48	..	..	...	.	...	
71	26 ...	eP	9	15	24	...	...	...	..	...	
		eL	9	30	12	...	...	...	.	...	
		M	9	32	48	...	...	50	...	...	
		F	9	49	00	...	...	...	...	...	
72	26 ...	eP	19	49	42	...	...	..	..	..	
		iL	19	54	24	...	...	...	...	...	
		M	20	14	24	...	...	150	...	...	
		F	20	50	48	...	..	...	...	.	
73	26 ...	eP	21	55	54	...	...		...	..	Widening of line.
		F	21	58	30	...	...	...	...	...	
74	26 ...	eP	22	07	12	...	...	..	...	...	Widening of line.
		F	22	11	30	...	...	...	...	...	
75	27 ...	eP	23	19	30	...	...	...		..	Widening of line.
		F	23	26	42	...	...	...	...	...	
76	October 3 ...	eP	10	37	24	...	...	...	...	...	
		iL	10	40	30	...	...	...	...	...	
		M	10	41	18	...	...	70	...	...	
		F	11	00	48	...	...	...	...	...	
77	4 ...	eP	6	25	00	...	...	...	...	...	Widening of line.
		F	6	26	06	.	...	..	...	..	
78	4 ...	P		...		...	...	.	...	...	No P.Ts.
		iL	17	55	12	...	...			...	
		M	17	57	42	.	...	210	...	...	
		F	18	20	48	...	...	..	.	..	
79	4 ...	eP	19	44	00	...	...	...	...	..	Widening of line.
		F	19	53	00	...	...	..	...	...	
80	9 ...	P		...		...	.	...	..	...	No P.Ts.
		eL	7	06	06		...	..	...	...	
		M	7	09	42	...	...	60	...	...	
		F	7	18	24	...	...	.	...	..	
81	10 ...	eP	2	10	18	...	...	...	...	...	Widening of line.
		F	2	22	30	...	...			...	
82	12 ...	eP	21	54	30	...	...	..	..	...	
		eL	21	59	12	...	...	...	...	...	
		M	22	07	00	...	...	260	..	...	
		F	22	43	48	...	...	...	...	...	

* No record from 18th 4h to 19th 4h 14m as the lamp did not burn.

No.	Date.	Phase.	Time G.M.T.	Period. (Sec.).	Amplitude (a).			Distance Δ (Km.).	Remarks.
					An.	Ae.	Az.		
	1919.		H. M. S.						
83	October 24 ...	eP	20 47 24	...	...	...	...	...	Widening of line.
		F	20 50 00	.	..	...	...	...	
84	31 .	eP	16 18 42	...	..	..	...	..	
		eL	16 22 18	..	...	.	...	...	
		M	16 25 24	...	...	70	...	...	
		F	16 43 48	...	..	..	...	...	
85	November 15 ...	eP	6 20 24	...	...	..	...	...	Widening of line.
		F	6 24 00	.	..	...	...	...	
86	18 ...	eP	22 19 12	...	...	...	...	..	
		eL	22 27 00	...	...	...	...	...	
		M	22 35 18	..	...	90	...	...	
		F	22 55 36	.	...	...	..	..	
87	20 ...	eP	14 34 48	...	...	..	...	..	
		eL	15 06 48	..	..	..	...	...	
		M	15 08 48	...		40	...	...	
		F	15 25 30	...	...	...	...	...	
88	December 14 ...	eP	2 06 54		..	.	...	.	
		eL	2 10 42	.		.	..	...	
		M	2 16 12	.	...	60	..	...	
		F	2 35 06	...	...	...	.	...	
89	20 ...	eP	19 58 42	...	...	...	..	...	
		eL	20 02 48	.	...	..	...	...	
		M	20 08 00	...	...	50	..	...	
		F	20 25 24	..	...	.	...	...	
90	20 ...	eP	20 45 54		..	...	...	...	
		iL	20 52 00	...	..	..	...	...	
		M	21 05 54		..	150	...	...	
		F	22 23 18	...	...	...	...	...	

APPENDIX II.

Latitude 10° 13′ 50″ N. Height of Barometer cistern above mean sea level 7688 feet.

Longitude 5h 9m 52s E.

MEAN Monthly and Annual Meteorological Results at the Kodaikanal Observatory in 1919.

Month.	Barometer.		Dry Bulb Thermometer.				Wet Bulb.		Tension of Vapour.	Relative Humidity.	Sun Max. in Vac.	Min. on Grass.	Wind.			Rain.		Clear Sky.	Bright Sunshine.
	Reduced to 32°.	Daily Range.	Mean.	Max.	Min.	Range.	Mean.	Min.	By Simpson's Tables.				Daily Velocity	Mean Direction.		Amount.	Days.		
	Inches.	Inches.	°	°	°	°	°	°	Inches.	Cents.	°	°	Miles.	Points	Points.	Inches.	No.	Cents.	Hours.
January	22·872	0·062	56·0	64·2	47·8	16·4	49·3	43·1	0·293	67	122·2	35·3	241	6	E.N.E.	5·24	6	63	259·6
February	·882	·060	57·6	67·4	47·9	19·5	48·3	41·0	·253	54	124·5	39·2	252	4	N.E.	0·33	1	69	260·2
March	·882	·066	59·4	69·1	49·8	19·3	49·1	43·1	·242	50	133·1	36·9	279	5	N.E. by E.	1·01	3	79	313·9
April	·847	·065	62·4	70·9	53·9	17·0	54·5	48·9	·353	64	134·4	45·1	234	6	E.N.E.	4·87	7	48	250·6
May	·807	·064	61·5	69·2	53·7	15·5	55·9	51·2	·398	76	132·5	47·2	215	17	S by E.	7·02	10	42	215·1
June	·753	·053	59·4	65·1	53·6	11·5	54·8	50·8	·395	82	122·3	49·6	408	24	W.	2·53	7	22	157·7
July	·751	·056	58·1	63·7	52·5	11·2	54·4	50·5	·397	85	122·2	48·2	345	24	W.	4·48	12	18	138·0
August	·789	·057	58·7	64·8	52·5	12·3	54·3	49·6	·390	82	124·7	47·8	309	24	W.	6·77	10	24	153·9
September	·796	·070	58·0	63·9	52·1	11·8	55·0	50·7	·411	87	120·7	47·2	184	19	S.W. by S.	11·68	17	18	118·0
October	·827	·065	58·1	64·4	51·7	12·7	54·3	49·9	·393	84	121·7	46·6	219	28	N.W.	8·44	15	32	164·6
November	·791	·067	55·5	61·5	49·5	12·0	51·6	47·3	·354	82	114·6	43·8	273	30	N.N.W.	8·30	13	32	145·9
December	·827	·062	55·2	61·9	48·5	13·4	50·9	45·3	·339	79	116·3	40·9	261	7	E. by N.	4·39	11	40	187·4
Annual	22·819	0·062	58·3	65·5	51·2	14·4	52·7	47·6	0·351	74	124·1	44·0	268	26	W.N.W.	65·06	112	41	2364·9

EXTREME Monthly Meteorological Records at the Kodaikanal Observatory in 1919.

Month.	Barometer.					Dry Bulb Thermometer.				Wet Bulb.		Humidity.		Sun Th. in Vacuo.		Grass Therm.		Wind.				Rain.	
	Highest.		Lowest.		Range.	Highest.		Lowest.		Lowest.		Lowest.		Highest		Lowest.		Highest.		Lowest.		Greatest Fall.	
	Inches.	Day.	Inches.	Day.	Inches.	°	Day.	°	Day.	°	Day.	Cents.	Day.	°	Day.	°	Day.	Miles.	Day.	Miles.	Day.	Inches.	Day.
January	22·958	6	22·773	17	0·185	69·6	1	**42·4**	**17**	**33·2**	**3**	9	3	133·7	20	**27·1**	**17**	436	5	146	29	2·06	28
February	**·972**	**5**	·786	22	·186	70·9	28	43·9	23	33·6	24	14	3	136·7	5	34·1	5	317	12	174	19	0·31	21
March	·952	20	·825	9 &27	·127	72·6	30	42·8	10	33·5	10	**7**	**10**	144·4	19	29·0	10	473	26	122	20	0·41	17
April	·939	22	·753	13	·186	**75·7**	**6**	50·3	6	43·0	4	21	3	148·9	16	38·8	1	367	3	160	9	1·18	20
May	·879	6	·715	28 &29	·164	72·4	2	51·8	19	46·1	31	35	31	145·7	17	42·3	2	394	31	134	26	1·92	7
June	·832	23	·646	5	·186	69·3	1	51·8	19	46·6	9	52	16	134·0	10	46·1	9	590	7	227	4	0·45	24
July	·834	14	**·643**	**30**	·191	68·2	24	51·2	3 & 4	42·6	29	55	9	144·5	22	44·0	13 & 21	**800**	**28 & 29**	110	16	0·83	20
August	·866	20	·694	1	·172	68·8	17	49·2	25	40·6	16	46	15	**149·5**	**17**	41·1	16	500	1	133	28	1·68	29
September	·906	11	·708	24	·198	66·5	27	49·2	2	44·9	2	59	1	138·9	15	37·7	2	335	9	**92**	**24**	2·17	19
October	·894	1	·770	18	·124	68·0	2	48·3	8	37·8	7	35	7	140·3	3	38·5	8	381	5 & 27	111	17	1·81	30
November	·900	24	·665	2	·235	67·2	27	44·6	17	36·4	17	26	15	136·1	22	32·9	17	578	3	109	21	**2·31**	**30**
December	·926	19	·742	14	·184	67·5	13	42·8	11	33·4	21	22	21	128·0	15	27·9	11	535	6	159	14	0·78	2

APPENDIX III.

KODAIKANAL mean hourly wind velocity for the year 1919.

Month.	Hours.																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	11	11	11	11	9	9	9	10	11	12	12	12	12	11	9	9	8	7	8	9	9	10	10	11
February	12	12	12	12	12	10	12	12	12	14	13	12	11	10	9	8	7	6	7	8	9	10	11	11
March	12	12	12	12	12	12	12	14	14	18	17	16	14	12	11	10	8	7	7	7	7	8	11	12
April	10	9	9	9	9	9	9	9	10	11	12	11	11	11	11	10	10	9	9	10	9	9	9	9
May	10	9	10	10	10	10	10	9	8	9	10	10	9	9	9	8	8	8	7	8	8	9	9	9
June	20	18	19	18	19	18	17	17	16	14	14	16	15	13	15	16	16	17	18	18	18	18	19	19
July	15	15	15	16	14	14	14	15	14	13	14	14	14	14	14	14	14	14	14	15	15	15	15	15
August	16	15	15	15	14	14	13	13	12	12	10	10	10	10	10	11	11	12	13	14	14	14	15	16
September	8	7	9	8	8	8	8	7	7	7	8	8	8	8	8	7	7	7	7	8	8	8	7	8
October	10	11	10	10	10	10	10	10	9	9	9	8	8	9	8	8	8	8	8	9	9	9	9	9
November	12	13	12	12	12	12	12	12	11	11	11	11	11	10	9	9	9	10	11	13	12	12	12	12
December	11	12	11	11	11	11	11	11	10	12	13	12	11	11	10	9	8	9	10	10	11	12	12	12
Mean	12	12	12	12	12	11	11	12	11	12	12	12	11	11	10	10	10	10	10	11	11	11	12	12

APPENDIX IV.

KODAIKANAL mean hourly bright sunshine for the year 1919.

Month.	Hours.											
	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18
January	0·23	0·80	0·81	0·88	0·92	0·89	0·84	0·82	0·79	0·69	0·61	0·72
February	·51	·95	·93	·94	·97	·97	·92	·79	·72	·73	·60	·25
March	·63	·88	·92	·96	·97	·95	·91	·90	·86	·82	·80	·53
April	·44	·82	·88	·91	·94	·89	·84	·75	·64	·63	·41	·20
May	·29	·68	·81	·88	·85	·78	·71	·61	·46	·39	·35	·13
June	·12	·40	·51	·66	·70	·61	·59	·53	·39	·35	·30	·08
July	·13	·47	·57	·56	·56	·49	·46	·37	·33	·28	·17	·06
August	·14	·53	·73	·64	·59	·61	·52	·38	·34	·30	·13	·04
September	·14	·42	·51	·62	·56	·45	·36	·39	·23	·14	·08	·04
October	·28	·47	·55	·69	·65	·62	·48	·45	·36	·38	·22	·05
November	·18	·50	·57	·58	·57	·50	·48	·44	·38	·37	·22	·06
December	·09	·53	·64	·68	·77	·68	·61	·55	·55	·48	·40	·03
Mean	0·26	0·62	0·70	0·75	0·75	0·70	0·64	0·58	0·50	0·46	0·36	0·18

APPENDIX V.

NUMBER of days in each month on which the Nilgiris were visible in 1919.

Month.	Very clear.	Visible.	Just visible.	Tops only visible.	Total.
January	...	8	2	2	12
February	...	14	2	1	17
March	2	8	...	2	12
April	...	...	...	1	1
May	...	8	...	1	9
June	1	4	...	...	5
July	...	11	...	...	11
August	...	8	4	...	12
September	2	9	1	1	13
October	1	11	...	...	12
November	3	10	...	...	13
December	...	11	1	1	13
Total	9	102	10	9	130

APPENDIX VI.

MADRAS OBSERVATORY.—Abnormals from monthly means for the year 1919.

Abnormals of	January.	February.	March.	April.	May.	June.	July.	August.	September	October.	November.	December.	Annual.
Reduced atmospheric pressure	+ 0·001	+ 0·017	+ 0·036	+ 0·003	+ 0·012	− 0·034	+ 0·075	− 0·004	+ 0·018	+ 0·016	− 0·065	− 0·028	− 0·003
Temperature of air	+ 3·2	+ 3·0	+ 0·5	+ 1·3	+ 1·6	+ 1·0	− 0·2	+ 2·7	+ 0·2	+ 1·1	+ 2·0	+ 1·7	+ 1·5
Do. of evaporation	+ 4·2	+ 2·8	+ 0·6	+ 1·5	+ 0·8	+ 0·4	+ 1·5	+ 1·3	+ 2·2	+ 1·9	+ 3·1	+ 2·3	+ 1·4
Percentage of humidity	+ 5	+ 1	normal	+ 1	− 2	− 8	+ 8	− 4	+ 8	+ 4	+ 5	+ 3	+ 2
Greatest solar heat in vacuo	+ 12·2	+ 14·7	+ 12·6	+ 13·5	+ 14·5	+ 4·2	+ 4·5	+ 10·0	+ 9·5	+ 12·9	+ 7·8	+ 5·3	+ 10·1
Maximum in shade	+ 0·7	+ 1·1	− 0·3	+ 0·7	+ 1·5	+ 0·5	− 1·3	+ 2·8	− 1·4	+ 0·2	+ 1·2	− 0·2	+ 0·4
Minimum in shade	+ 4·6	+ 3·4	− 0·1	+ 1·5	+ 0·5	+ 0·5	+ 0·3	+ 1·7	− 0·2	+ 1·1	+ 2·1	+ 2·5	+ 1·4
Do. on grass	+ 6·1	+ 4·6	+ 1·0	+ 2·2	+ 1·1	+ 1·2	+ 0·3	+ 1·6	+ 0·3	+ 1·9	+ 3·2	+ 4·1	+ 2·4
Rainfall in inches	− 0·52	− 0·28	+ 1·57	− 0·62	− 2·09	+ 0·38	+ 2·29	− 1·44	+ 2·09	− 0·20	− 0·38	+ 0·96	...
Do. since January 1st	...	− 0·80	+ 0·77	+ 0·15	− 1·94	− 1·56	+ 0·73	− 0·71	+ 1·38	+ 1·18	+ 0·80	+ 1·76	+ 1·76
General direction of wind	1 point E.	2 points S.	normal	normal	normal	2 points W.	1 point S.	2 points W.	4 points E.	4 points N.	2 points E.	normal	normal
Daily velocity in miles	− 57	− 31	− 35	− 18	− 71	− 45	− 52	− 28	− 72	− 60	− 79	− 42	− 49
Percentage of cloudy sky	− 1	+ 4	− 11	− 1	− 5	+ 7	− 8	− 1	− 13	− 2	+ 2	+ 12	− 2
Do. of bright sunshine	− 4·4	− 5·7	− 3·7	− 0·1	− 3·4	− 12·3	+ 4·9	− 1·9	+ 6·5	− 8·7	− 5·9	− 12·3	− 8·4

\+ means *above* normal ; − means *below* normal.

APPENDIX VII.

ABSTRACT of the Mean Meteorological Condition of Madras in the year 1919 compared with the average of past years.

Mean values of	1919.	Difference from	Average.
Reduced atmospheric pressure	29·861	0·003 below.	29·864
Temperature of air	82·6	1·5 above.	81·1
Do. of evaporation	75·9	1·4 above.	74·5
Percentage of humidity	74	2 above.	72
Greatest solar heat in *vacuo*	149·8	10·1 „	139·7
Maximum in shade	91·2	0·4 „	90·8
Minimum in shade	76·1	1·4 „	74·7
Do. on grass	74·3	2·4 „	71·9
Rainfall since January 1st on 90 days	50·78	1·76 „	49·02
General direction of wind	S.E.	Nil.	S.E.
Daily velocity in miles	122	49 below.	171
Percentage of cloudy sky	47	2 „	49
Do. of bright sunshine	50·0	8·4 „	58·4

DURATION and quantity of the wind from different points.

From	Hours.	Miles.	From	Hours.	Miles.	From	Hours.	Miles.	From	Hours.	Miles.
North.	195	1054	East.	108	518	South.	146	759	West.	235	1893
N. by E.	334	1845	E. by S.	301	1274	S. by W.	218	1103	W. by N.	170	1160
N.N.E.	229	1454	E.S.E.	256	1205	S.S.W.	156	797	W.N.W.	142	880
N.E. by N.	281	1969	S.E. by E.	717	3543	S.W. by S.	188	1032	N.W. by W.	105	724
N.E.	155	977	S.E.	557	3276	S.W.	217	1159	N.W.	58	332
N.E. by E.	133	827	S.E. by S.	901	5907	S.W. by W.	215	1241	N.W. by N.	56	200
E.N.E.	76	431	S.S.E.	318	2395	W.S.W.	199	1334	N.N.W.	37	196
E. by N.	144	691	S. by E.	290	1678	W. by S.	310	2074	N. by W.	139	653

There were 1174 calm hours during the year. The resultant corresponding to the above numbers is represented by a S.E. by S. wind, blowing with a uniform daily velocity of 29 miles.

APPENDIX VIII.

MADRAS OBSERVATORY.—Number of hours of wind from each point in the year 1919.

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	13	27	29	104	69	48	22	36	27	40	22	83	...	...	...	...	...	...	..	...	..	...	...	..	...	...	...	...	...	...	...	...	224
February	...	...	...	..	...	2	...	21	37	104	141	190	18	19	3	3	...	2	1	1	3	3	...	...	...	...	...	...	...	...	...	...	124
March	2	1	...	...	...	1	...	15	2	1	15	175	196	185	19	34	7	10	7	2	2	2	2	2	.	1	...	2	1	1	1	4	54
April	...	...	...	...	...	...	..	...	...	...	...	78	93	308	109	29	13	18	9	10	1	1	...	6	...	...	2	...	...	...	1	5	37
May	1	3	..	1	1	.	2	7	5	11	7	48	132	186	40	43	29	26	20	10	27	25	12	12	20	19	16	12	1	4	2	3	19
June	14	8	1	5	4	3	2	5	3	11	9	10	14	19	23	27	9	22	39	31	53	42	59	98	66	48	42	25	7	5	1	4	11
July	1	1	...	1	1	...	1	2	2	6	12	32	18	84	53	39	12	33	24	48	53	39	58	67	54	23	18	15	23	8	4	...	12
August	1	...	2	1	1	1	...	1	...	2	9	23	13	11	10	37	30	40	33	50	44	63	45	87	70	43	41	39	18	11	...	1	17
September	1	2	1	3	4	16	3	5	5	44	22	51	62	72	42	40	9	35	19	24	20	22	11	18	7	14	2	3	...	4	4	2	153
October	12	53	23	35	17	19	10	18	4	19	16	18	3	1	9	26	37	28	3	12	13	16	10	20	18	20	3	4	2	17	9	29	220
November	64	56	49	29	18	23	16	30	23	24	3	9	8	16	10	12	...	4	1	...	1	2	2	...	...	2	18	5	6	6	15	59	209
December	86	183	124	102	40	20	20	4	...	39	...	...	...	.	...	..	...	...		...	...	...	...	...	...	.	...	...	..	..	...	32	94
Annual total	195	334	229	281	155	133	76	144	108	301	256	717	557	901	318	290	146	218	156	188	217	215	199	310	235	170	142	105	58	56	37	139	1174

APPENDIX IX.

MADRAS OBSERVATORY.—Number of miles of wind from each point in the year 1919.

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	Total.
January	94	141	136	648	346	310	118	165	151	146	74	353		...	...	...	..	...	...	...	..	...	...	...	.	. .	..	...	...	...	.	.	2682
February	...	...	...	...	..	8	...	91	152	471	628	909	106	86	19	24	..	13	8	5	13	13	...	...	..	...	...	...	.	..	..	..	2546
March	9	12		...	...	5	...	48	26	4	55	803	974	1057	168	185	48	66	42	19	12	12	16	7	...	4	...	7	4	4	7	35	3629
April		.	...	...	...	...	...	.	...	..	..	387	605	2397	984	270	112	168	86	103	9	7	...	14	...	.	20	...	...	...	2	25	5189
May	8	18	...	11	8	..	13	58	41	87	52	315	945	1259	318	230	150	133	117	73	129	154	85	86	162	146	88	81	9	22	19	14	4831
June	64	38	14	32	30	11	20	40	18	57	61	81	97	135	188	205	70	118	184	180	286	338	468	807	705	420	284	175	59	21	8	23	5237
July	9	5	...	5	6	...	5	16	15	44	66	161	132	480	374	250	72	153	117	280	366	244	380	388	412	139	127	104	132	29	14	...	4525
August	6	..	10	10	6	8	.	10	...	9	69	172	92	56	79	252	168	217	157	198	230	323	293	606	516	302	288	315	97	45	..	5	4539
September	7	10	9	6	14	35	20	29	17	159	106	243	254	379	211	171	44	123	64	125	78	87	60	62	52	62	13	21	.	26	27	8	2522
October	29	243	108	141	86	58	37	74	6	61	75	57	8	5	35	68	95	105	18	49	34	61	27	104	46	82	13	5	6	42	53	109	1940
November	268	339	332	174	153	190	85	148	92	119	19	62	63	53	19	23	...	7	4		2	2	5	..	...	5	47	16	25	11	66	248	2577
December	560	1039	845	942	328	202	133	12	...	117	.	..	...	...	...	...	..	...	...	...	...	..	...	...	...	...	...	..	...	...	...	186	4364
Annual	1054	1845	1454	1969	977	827	431	691	518	1274	1205	3543	3276	5907	2395	1678	759	1103	797	1032	1159	1241	1334	2074	1893	1160	880	724	332	200	196	653	44581

APPENDIX X.

MADRAS OBSERVATORY.—Number of inches of rain from each point in the year 1919.

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	0·01	0·06	...	...	...	...	...	...	...	..	0·30		...	..	...	...	...	..	...	...	..	..		..	...	...	...	...	...	...	...	..	...
February	...	...	...	...	...	...	...	...	...	..	...	...	...	...	...	..	...	...	..		.	...	...	...	...	...	...	...	...	...	...	...	...
March	0·01	0·03	...	...	...	0 78	...		0·77	...	...	0·24	..	..	...	.	...	..	...	...	..	...	..	...	...	...	...	..		...	...	0·13	..
April	...	...	..	..	...	...	...	...	...	...	...	...	...	...	..	...	...	...	..	.	...	..	...	...	...	...	...	...	.	...	...	...	.
May	...	0·02	...	.	..	...	...	...	. .	...	...	..	.	...	...	..	...	0 01	...	...	...	...	...	...	...	..	...	...	...	..	...	...	..
June	0·75	0·05	...	0·61	...	...	...	0 02	...	...	0 08	...	...	...	...	...	0·08	0·01	0·33	0 06	0·24	...	...	0·10	0·06	0·01	...	0·09	...	.	...	..	...
July	...		...	...	...	..	...	...	...	...	...	...	..	0 08	0·23	0·04	0·02	0·35	0·53	1·69	0 75	1·16	0·15	0·68	0·15	...	0·12	0 06	0·06	..	0 04	...	0 05
August	...	...	...	...	0·01	...	...	...	...	...	...	0·04	0·56	..	...	0·38	0 11	0·01	0·03	0·04	0·08	0·02	0·13	0·88	0·45	0·11	0·03	...	0 18	0·06	...	...	...
September	...	...	...	0·04	0·23	...	...	...	0·12	..	0·06	0 05	1 54	0·06	...	0·03	...	0·47	1·13	0·47	0·48	0·76	0·29	0·16	...	...	..	...	...	0·44	0·14	...	0·31
October	0·27	1·70	0·10	1·33	0·06	0·12	0 05	0·15	...	...	1·03	...	1·02	...	...	0·26	0·12	0·59	...	..	0·04	...	...	...	0·01	0·35	...	0·42	..	0·10	0·10	1·20	1·78
November	2·38	1·27	0·41	0·50	1·38	1·37	0·24	...	0·94	0·22	0·09	0·63	0·01	...	...	0·14		...	...	...	...	...	...	...	...	...	..	1·10	...	...	...	0·56	1·59
December	0·41	0·68	0·94	0·79	0·96	0·56	0 39	...	...	0·45	...	...	..	...	...	.	...	...	...	...	...	...	...	..	...	...	...	...	...	...	...	0·86	0·20
Annual	3·83	3·81	1·45	3·27	2·64	2·83	0·68	0·17	1·83	0·67	1·56	0·96	3·13	0·14	0·23	0·85	0·33	1 44	2·02	2·26	1·59	1·94	0·57	1·82	0·67	0·47	0·15	1·67	0·24	0·60	0·28	2·75	3·93

APPENDIX XI.

MADRAS OBSERVATORY.—Wind, cloud and bright sunshine, 1919.

Month.	Wind resultant.		Cloud (0—10).					Bright sunshine.	
	Velocity.	Direction.	8 H.	10 H.	16 H.	20 H.	Mean.	Average per day.	Greatest number of hours in a day.
	MILES.	POINTS.						HOURS.	HOURS.
January	71	N E. by E.	3·5	4·9	3·5	2·4	3·6	7·3	8·8
February	85	E.S.E.	2·6	4·5	2·7	1·2	2·8	8·4	10·3
March	108	S.E.	1·3	2·4	0·7	0·8	1·3	8·4	10·0
April	161	S.E. by S.	4·4	3·3	1·8	1·3	2·7	8·6	10·1
May	100	S.S.E.	3·6	3·2	4·0	2·4	3·3	7·2	9·4
June	106	W.S.W.	6·0	5·6	9·2	7·6	7·1	3·5	7·7
July	81	S.W. by S.	7·1	5·8	6·2	6·1	6·3	4·6	8·8
August	92	W.S.W.	6·8	5·6	7·6	6·2	6·6	4·6	9·1
September	49	S.S.E.	5·5	5·4	5·4	3·4	4·9	5·8	9·9
October	12	N N.E.	5·4	6·1	6·6	4·6	5·7	4·9	9·7
November	58	N.E. by N.	6·3	7·2	6·3	4·4	6·1	4·8	9·1
December	125	N.N.E.	6·5	6·7	6·7	5·6	6·4	4·6	8·3
Annual	29	S.E. by S.	4·9	5·1	5·1	3·8	4·7	6·1	...

APPENDIX XII.

MEAN Monthly and Annual Meteorological Results at the Madras Observatory in 1919.

Month.	Barometer.		Dry Bulb Thermometer.				Wet Bulb.		Tension of Vapour.	Relative Humidity.	Sun Max. in Vac.	Min. on Grass.	Wind.			Rain.		Cloudy sky.	Bright Sunshine.
	Reduced to 32°.	Daily Range.	Mean.	Max.	Min.	Range.	Mean.	Min.	By Simpson's Tables.				Daily Velocity.	Mean Direction.		Amount.	Days.		
	Inches.	Inches.	°	°	°	°	°	°	Inches.	Cents.	°	°	Miles.	Points	Points.	Inches.	No.	Cents.	Hours.
January	29·998	0·117	78·3	85·3	72·1	13·2	73·4	70·6	0·758	78	150·6	69·2	87	6	E.N.E.	0·37	1	36	225·0
February	·981	·116	79·7	87·7	71·4	16·3	73·6	70·3	·746	74	154·4	68·4	91	10	E.S.E.	..	..	28	233·9
March	·941	·130	80·5	88·9	72·0	16·9	74·5	70·9	·771	74	153·1	69·6	117	12	S.E.	1·96	2	13	261·0
April	·829	·133	85·3	93·6	78·7	14·9	79·1	76·8	·908	75	155·2	76·9	173	13	S E. by S.	...	...	27	258·3
May	·747	·114	88·3	99·3	81·3	18·0	79·1	76·3	·869	65	157·5	80·0	156	15	S. by E.	0·03	2	33	224·4
June	·669	·116	87·4	98·8	80·8	18·0	77·0	74·0	·784	61	144·7	79·8	175	21	S.W. by W.	2·49	12	71	105·3
July	·709	·123	84·3	94·3	78·2	16·1	77·4	74·3	·846	73	143·2	76·9	146	19	S.W. by S.	6·16	12	63	143·1
August	·746	·125	86·0	96·5	79·0	17·5	77·3	73·8	·816	66	150·0	77·0	146	21	S W. by W.	3·12	8	66	143·8
September	·795	·132	83·2	91·8	76·9	14·9	78·5	75·7	·906	80	150·8	75·3	84	14	S S E.	6·78	10	49	174·3
October	·857	·119	81·7	89·2	76·3	12·9	77·5	74·5	·884	82	152·0	74·7	63	3	N.E. by N.	10·80	16	57	151·1
November	·859	·107	79·5	86·2	74·4	11·8	73·4	76·0	·850	84	145·2	72·7	86	4	N.E.	12·83	14	61	143·8
December	·950	·108	77·2	83·4	72·3	11·1	70·3	72·9	·749	80	141·1	70·5	141	3	N.E. by N.	6·24	13	64	142·3
Annual	29·840	0·119	82·6	91·2	76·1	15·1	75·9	73·8	0·824	74	149·8	74·3	122	12	S E.	50·78	90	47	2206·3

EXTREME Monthly Meteorological Records at the Madras Observatory in 1919.

Month.	Barometer.					Dry Bulb Thermometer.				Wet Bulb.		Humidity.		Sun Th. in Vacuo.		Grass Therm.		Wind.				Rain.	
	Highest.		Lowest.		Range.	Highest.		Lowest.		Lowest.		Lowest.		Highest.		Lowest.		Highest.		Lowest.		Greatest Fall.	
	Inches.	Day.	Inches.	Day.	Inches.	°	Day.	°	Day.	°	Day.	Cents.	Day.	°	Day.	°	Day.	Miles.	Day.	Miles.	Day.	Inches.	Day.
January	**30·130**	**6, 15**	29·872	25	0·258	87·4	30	**64·5**	**2**	**63·5**	**2**	57	1	155·6	19	**61·2**	**2**	182	6	34	30	0·37	4
February	·121	5	·820	18	·301	93·5	18	68·4	23	67·4	23	54	24	162·8	12	65·2	23	126	18	43	1	...	...
March	·061	20	·761	31	·300	94·9	31	66·4	10	64·6	10	48	9	159·2	2	69·6	10	196	18	65	8	1·72	20
April	29·962	21	·796	13	·166	98·3	23	73·7	5	72·7	5	43	23	163·6	23	71·3	5	248	24	111	5	..	...
May	·885	3	·579	31	·306	**108·2**	**21**	76·5	9	72·4	19	29	22	165·6	20	75·2	9	205	5	124	13	0·02	8
June	·792	23	·523	30	·269	105·0	18	70·2	3	69·7	3	**25**	**18**	159·1	2	70·5	3	245	14	50	4	0·91	3
July	·846	14	**·519**	**30**	·327	102·2	3	73·5	11	72·3	2	35	1	154·3	4	72·9	11	200	4	86	20	1·25	9
August	·858	6	·602	1	·256	101·1	14	74·0	22	71·3	24	34	13, 14	162·0	29	73·2	5	201	14	97	20	0·97	18
September	·961	11	·606	1	**·355**	99·0	1, 2	73·3	15	72·9	15	38	1	**164·5**	**12**	72·2	5	140	6	32	24	**3·18**	**28**
October	·963	14	·721	6	·241	96·2	8	73·1	23	71·6	23	57	15	163·0	19	67·9	20	96	22	**24**	**14**	2·62	31
November	30·023	24	·699	13	·324	90·6	17	70·5	26	69·8	26	62	18, 25	158·4	13	67·3	26	200	30	**24**	**19**	3·08	5
December	·110	19	·795	14	·315	86·3	17	67·4	11	64·8	21	54	11	157·4	16	64·1	11	**320**	**30**	**24**	**14**	1·76	31