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G.O., DATED 24-3-93
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[Despatch Abstract.]

Recd letter from the
Meteorological Reporter of the
Govt of India for sending copy
of his report & letter regarding
the new Imperial Observatory
at Kodaikanal & the establishment of a
Solar Physics Observatory at
Kodaikanal & the continuation
of the Indian Astronomical
Observatory at Kodaikanal.

Current No. 856

Public Department.

From Meteorological Reporter to
Govt of India.

No. 169/00

Dated 13th

Received 20th } March 1893
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Enclosures 5. s.e. each of 2 enclosures.

SUBJECT.

Regarding the best site for the
new Imperial Observatory & the Establishment
of a Solar Physics Observatory at
Kodankanal etc

150 222-2-93
No 3 24-1-93
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22 March

Original of 13th March 1893
sent to the Secretary
to the Government
of India, for his
information.

FURTHER PAPER, No.

OF 18

241
24-3-93
1020 of 93
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READ AGAIN ORDER OF GOVERNMENT, DATED
18, No. , MISCELLANEOUS.

ENCLOSURES.

CURRENT No.

STATEMENT WITH DITTO.

ORDER OF GOVERNMENT.

LETTER OF GOVERNMENT.

STATEMENT WITH DITTO.

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decision of the Government as to the
future work and status of that
observatory -

I have the honor to be,
Sir

Your most obed^t servant -

John Hunt

Meteorological Reporter to
the Government of India

positions of lines, also for recording the same on smoked glass (not reliable) ; set of positive and negative eye-pieces and a filar micrometer eye-piece.

With a single reversal, *i.e.*, employing "6 prisms" and a high power, all the lines in *Vogel's large map* of the solar spectrum can be recognized. The spectroscope is intended for all kinds of solar work ; spectra of spots and faculae, chromospheric bright lines, and for observing and measuring prominences. It was constructed under the directions of the late Colonel Strange, and is the one with which Professor Lockyer made his observations of the widening of the lines in solar spots prior to 1885.

Probably all that is required to make this complete for the work desired is a diffraction grating, and a camera and a dome for its reception.

FROM

No. 1693
 THE METEOROLOGICAL REPORTER
 TO THE GOVERNMENT OF INDIA,

TO

THE *Chief Secretary to the Government of Madras*

Dated Simla, the *3rd March* 1893.

SIR,

I have the honor in compliance with the orders of the Government of India to send you copies of my report on the best site for new Imperial observatory and of my letter No. 149 dated 4th March 1893 to the Government of India containing my recommendation for the establishment of a Solar Physics observatory at Kodakana and the continuance of the Madras Astronomical observatory on a tentative footing pending the final decision.

5 copies each

Rs.

Solar Physics Observatory—

First observer, Rs. 200 to Rs. 300	...	...	...	3,300
Second observer, Rs. 100 to Rs. 150	...	...	...	1,650
Third observer, Rs. 50 to Rs. 75	...	...	...	825
Two menial assistants on Rs. 15 to Rs. 25	...	...	...	540
One Writer, Rs. 30 to Rs. 50	...	...	...	540
Peons, &c.	...	...	...	500
Contingencies	...	...	...	1,000
TOTAL				25,715

24. It would probably be advisable to have a European, for example a Sergeant in the Royal Engineers, who has been trained at South Kensington as first or spectroscopic observer. If a competent native observer could be obtained, the pay of the first observer might be reduced. The photographic observer at Dehra Dun would probably be willing to go in that capacity to Kodaikanal. His present pay is Rs. 135 to Rs. 150.

25. If Miss Pogson were appointed Assistant Superintendent and her Meteorological Office were located in the observatory offices, there would be a saving of Rs. 50 per mensem for rent. The location of her office in the observatory building would probably give greater facilities for the preparation of Daily Weather Report for Madras, if it should be decided to commence it, than her present office.

26. It may also be noted that the continuation of the Solar Photographic Records during the transfer of the photographic observatory at present at Dehra Dun could be easily secured by removing one dome to Kodaikanal, and continuing the observations with the second instrument at Dehra Dun until the first instrument and its dome were placed in position at Kodaikanal.

I have the honor to be,

SIR,

Your most obedient Servant,

JOHN ELIOT,

Meteorological Reporter to the Government of India.

APPENDIX I.

1. The following gives a brief description of the apparatus in use at Dehra Dun for photographing the sun, and which would be available for that work at Kodaikanal :—

I.—Smaller Photo-Heliograph—

Objective	...	...	...	4 inches diameter.
Length of Telescope (including Camera)	...	...	...	9 feet 3 inches.
Height of iron stand	...	...	...	6 feet 4 inches.
Size of solar picture	...	...	...	8 inches.
Masonry Pillar, 5 feet 4 inches diameter.	Height above plinth, 17 feet 7 inches, with a foundation of probably 5 feet. Estimated weight, 60 maunds. Cost of dome and observatory not known.			

II.—Larger Photo-Heliograph—

Objective	...	...	...	6½ inches diameter.
Length of Telescope (including Camera)	...	...	...	15 feet 9 inches.
Height of iron stand	...	...	...	9 feet 6 inches.
Size of solar picture	...	...	...	12 inches.
Masonry Pillar, 6 feet 1 inch diameter at plinth and 3 feet 9 inches at top.	Height above plinth 12 feet 2 inches, probable foundation 5 feet. Weight, 100 maunds. Dome, cost Rs. 5,000 in addition to the cost of observatory, which was about Rs. 15,000.			

2. For the spectroscopic work there is available the telescope and adjuncts constructed, I believe, for the last transit of Venus observations in India, and at present lent to the Poona College of Science. The following gives a statement of the parts, &c. :—

Telescope, 6 inches aperture, 7 feet focus.

Cast iron pillar, universal adjustment in latitude and clock work.

Finder, 1½ inches aperture.

Six eye-pieces, ordinary Huyghenian, with dark glass caps.

First surface reflection prism for viewing the sun and for use as star total reflection prism.

Transit eye-piece.

Large filar micrometer, with position circle.

Iris Diaphragm for contracting the aperture of the lens.

Prismatic illuminating arrangement.

Level for determining the horizontality of the declination axis.

Declination circle, 16 inches diameter, divided on silver. [This has been slightly damaged.]

Right ascension circle, 16 inches diameter, silver.

Clamping arrangements worked from eye-end.

Adjustable counterpoise for spectroscope.

Spectroscope by Hilger. Three prisms of 60°, 4 inches height, with arrangement to use dispersion of 2 to 18 prisms by reversion of the beam.

Collimator telescope, 1 inch aperture.

Large position circle and arrangement to observe the chromosphere and prominences both tangentially and radially, supplied with a long micrometer screw for taking rapid

claims to pension. It is, I believe, generally felt that she has been somewhat hardly treated in this matter. The appointment, I suggest above, would in some respects be similar in character to that of which she was deprived. The Government may hence perhaps be disposed to take this fact into consideration as an additional reason why, if the appointment be created, it might be first offered to Miss Pogson.

19. When I was in Madras in January, I consulted with the Madras authorities as to their views and wishes with respect to the observatory. I learnt that there would probably be no objection to handing over the Madras Observatory (including the grant for its maintenance and buildings) to the Government of India, or to the control of the observatory being in future entirely in the hands of the Government of India. The only point on which the Government of Madras expressed a strong opinion was with respect to the desirability of retaining Mr. Michie Smith's services. They considered that he was, by his special scientific attainments and knowledge of the conditions of scientific work of India, peculiarly fitted for the appointment of Director of the Solar Physics Observatory, and that his services in carrying out the publication of the Madras Observations had been especially valuable, and deserved full recognition.

20. The cost of the Madras Observatory during the past two years has averaged about Rs. 18,000 per annum. The annual cost of the Solar Photographic branch at Dehra Dun is about Rs. 3,000; so that the present expenditure on the Madras and Dehra Dun Observatories is about Rs. 21,000. Hence, a total yearly grant of about Rs. 21,000 is available for the new arrangements.

21. The following gives a rough estimate of the initial expenditure in starting the observatory at the Palnis:—

There would be required quarters for the Director, three domes (two of which would be sent from Dehra Dun), two office rooms (a small one for the Director and a large one for the observers, &c.), a photographic room and a small workshop, and also detached quarters for the observers and servants. Mr. Michie Smith, whom I consulted, thought that the whole of the requisite buildings, if constructed in a somewhat temporary manner, would probably cost less than Rs. 20,000. So far as I can estimate, I think from Rs. 20,000 to Rs. 25,000 would be sufficient to provide buildings for the next five years, during which the question of the transfer of the Madras Astronomical Observatory would probably be in abeyance.

The apparatus in use at Dehra Dun would probably be ample for the requirements of the photographic work, whilst the telescope and the spectroscopic apparatus at present at the Poona College of Science, but which will be handed over to the Solar Physics Observatory as soon as it is required, will probably suffice, with some slight addition for the spectroscopic work. A list of the available apparatus is given in Appendix I, in order that the Solar Physics Committee may suggest whether it would suffice for present requirements or not.

A good astronomical clock, diffraction grating, heliostat, mean time chronometer and workshop tools including a lathe, would undoubtedly be required. The cost of the apparatus required would almost certainly be less than

Rs. 7,500 and perhaps less than Rs. 6,000. The initial expenditure would hence probably be more than Rs. 25,000, but less than Rs. 32,500.

22. The following would be the staff that I should suggest for the combined reduced Madras Astronomical Observatory and the Solar Physics Observatory, including the arrangements:—

1st—For the Solar Physics Observatory.

2nd—For the Madras Observatory current work.

3rd—For the preparation of the unpublished Madras series of observations for publication.

I have already suggested that Mr. Michie Smith should be appointed Director of the Solar Physics Observatory; his pay should not be less than Rs. 800 per mensem, his present pay, and it might perhaps be fixed at Rs. 800 rising to Rs. 1,200 by annual increments of Rs. 50 (as suggested in my first memorandum). Considering the character and importance of the work and the present value of the rupee, it would, I believe, hardly be possible to obtain from England a man of Mr. Michie Smith's qualifications and experience for that salary.

There would be required for the observatory three observers, one for each branch of the work, and perhaps two menial assistants, a writer and the usual peons, &c.

Two clerks would probably suffice to assist Mr. Michie Smith in the publication of the volumes of the Madras Observations. It would probably be found that this work could be done at Madras, and that two of the present staff could be selected for this work.

The Assistant Superintendent would require at least two clerks for the time-ball and meteorological work. If Miss Pogson were appointed, she would be provided with quarters in the Observatory, and a small personal allowance of Rs. 100 would probably be sufficient to secure her services.

23. The following is an approximate statement of the annual cost of these arrangements:—

	Rs.
Director of Solar Physics Observatory and Superintendent, Madras Observatory, Rs. 800 to Rs. 1,200	12,800
Assistant Superintendent, Madras Observatory, at Rs. 100 per mensem	1,200
Madras Observatory—	
For Time and Meteorological observations—	
1 Clerk on Rs. 60*	720
1 Do. „ 40*	480
For preparation of volumes of Madras Observations for Press—	
1 Clerk on Rs. 100*	1,200
1 Do. „ 80*	960

* These clerks are on the present establishment and paid at these rates.

quence of the very varying amount of dust haze in the atmosphere in Northern India during fine clear weather, and partly in consequence of imperfection in the instruments used for these observations.

11. The establishment of a Solar Physics Observatory at the most suitable hill station in Southern India, under a qualified Director, would enable the photographic and spectroscopic work to be carried out under probably the best and most suitable conditions obtainable in India. Actinometric observations should also be made under the same conditions.

12. It is probable that a much larger number of fairly satisfactory actinometric observations can be made on days fairly comparable with each other, so far as the atmospheric conditions affecting the absorption of the heat rays of sun are concerned at a hill station in Southern India (*e.g.*, Kodaikanal) than at Simla. It is, however, doubtful whether the finest days at Kodaikanal for actinometric observations would be equal to those at Simla on clear days immediately after heavy snow or rain, when the atmosphere is remarkably transparent and clear and light northerly breezes oppose the transfer of dust from the plains to the hills. It would hence, on the one hand, be desirable to include actinometric observations in the range of work at the Solar Physics Observatory, and on the other, to continue them at Simla, confining them at the latter place to the exceptionally fine days in the year described above, when such series of observations extending over the whole day should be made.

13. Hence the early establishment of a Solar Physics Observatory appears to be an urgent necessity—firstly, on account of the importance of the work, and secondly, on account of the imperfect and temporary nature of the present arrangements for the performance of the work. And, as has been established by the comparative observations taken during the past twelve months at the hill stations of Southern India (of which a full report accompanies this letter), the most suitable site for the Solar Physics Observatory would be on the Palni Hills near Kodaikanal. This conclusion it may be noted, though based on the results of the meteorological observations, is confirmed by the results of astronomical test observations taken by Mr. Michie Smith at Kodaikanal and Kotagiri (*vide* his report on this subject).

14. I have hence the honor to suggest that the consideration of the question of the permanent site of the Astronomical Observatory, its future work, equipment and establishment should be postponed for some time, say five years; and that a Solar Physics Observatory should be established on the Palni Hills in such a manner as to secure—

1st—Photographic, spectroscopic and actinometric solar observations according to general methods, to be prescribed by the Solar Physics Committee, and hence probably in accordance with the methods in use at similar observatories in England, the United States and the Continent of Europe.

2nd—The completion of the publication of the Madras series of observations taken during the past 30 years, so far as they are likely to be of value for scientific purposes.

3rd—The continuation of the time determination and meteorological observations at Madras as during the past two years.

Five years' solar and other observations at Kodaikanal would afford ample data to settle finally, when the matter arose for discussion, whether that

station or Madras would be best adapted for the future astronomical work of a fully equipped astronomical observatory in Southern India.

16. The preceding objects would be most satisfactorily and easily obtained by the following arrangements:—

1st—The early establishment of a Solar Physics Observatory on the Palni Hills near Kodaikanal, and the appointment of Mr. Michie Smith as the Director and also as Superintendent of the Madras Astronomical Observatory until the appointment of an Astronomer.

2nd—The appointment of an Assistant Superintendent at the Madras Observatory, who would live in the Observatory and be in charge of the instruments, and superintend the performance of the ordinary transit and time-ball work and meteorological observations, subject to the orders of Mr. Michie Smith.

17. The early appointment of Mr. Michie Smith would secure several minor collateral advantages in addition to that of continuity in the publication of the Madras Astronomical Observations. His services might be utilized to assist in the preparation of plans for the new buildings, to select the most suitable site for the observatory on the Palnis, and to choose and train the native observers so far as is possible before the commencement of the work. His knowledge of the topography of the Palni Hills would make his assistance in the selection of the site for the observatory invaluable.

18. As he would have probably to be frequently at Kodaikanal, if he were employed in choosing the site and superintending the erection of the building, it would be desirable that the Assistant Superintendent should be shortly appointed. It would necessarily be a temporary and a local appointment. I would suggest Miss Pogson for the appointment for the following reasons:—

1st—She was Assistant for many years to her father at the Madras Observatory and helped in the work of observation and reduction of the observations to an extent that would more than qualify her for the comparatively simple work of superintending time determination and time-ball work at Madras. Her father frequently reported very favourably on her work. It is also noted specially in these reports that she discovered two Nebulæ and reduced observations of 193 phenomena of the Satellites of Jupiter between the years 1862 and 1881. There can hence be no doubt as to her qualifications for the work of superintending the time determination and meteorological observations, and she would be peculiarly fitted by her previous long connection with the observatory to look after the various astronomical telescopes, pending the final decision as to the future of the Madras Astronomical Observatory.

2nd—Miss Pogson was, after many years' service as Assistant to the Government Astronomer, deprived of the appointment; and although it was a pensionable appointment, she has not only received no compensation pension, but has been informed that she has lost all

star occultations between 1862 and 1880. Phenomena of Jupiter's Satellites on 193 occasions between 1862 and 1880. Measures of Alpha Centauri, Gamma Virginis and a few other double stars. Spectroscopic measures of Gamma Argus.

- (c) Determination of the constant of Solar Parallax, by means of 212 differential measurements of the planet Mars, in Right Ascension, from adjacent comparison stars, made with the Equatorials, on 104 evenings near the rising and 108 mornings near the setting of the planet, at its eight oppositions, in the years 1862, 1864, 1869, 1871, 1873, 1875, 1877 and 1879.

In addition to these observations of Mr. Pogson's, there are the following series of observations taken under previous Directors of the Madras Astronomical Observatory :—

- E. (a) A quarto volume of about 300 pages; containing observations made under the successive superintendence of T. G. Taylor, Esq., Captain W. S. Jacob, Bombay Engineers, and Major W. K. Worster, Madras Artillery, all prior to 1860. These observations comprise 1,331 of the Sun, 345 of the Moon, 1,680 of the principal planets, 333 of minor planets and 25 of Donati's comet of 1858. Also a long list of occultations of planets and stars, and of the eclipses of Jupiter's Satellites.
- (b) Separate results of observations made with the Transit Instrument and the Mural Circle in 1853, 1854, 1855 and 1856; with the deduced catalogues for each year.
- (c) Separate results of observations made with the Transit Instrument and the Mural Circle in 1857, 1858 and 1859, with the deduced catalogues for each year.
- (d) Catalogue of about 2,200 stars, for the Epoch 1855; from observations made with the Transit Instrument and Mural Circle between the years 1853 and 1858, under the superintendence of Captain W. S. Jacob, Bombay Engineers, and Major W. K. Worster, Madras Artillery.

7. It is doubtful how far it would be desirable to publish the last results in group E above; and before doing so the whole question of the errors of these old observations would have to be taken up fully, and this would probably require much time, and might result in the conclusion that the observations were not worth the labour that their preparation for publication might entail.

It would, I have the honor to suggest, be advisable that this matter should be referred to the Observatories Committee, in order that they might record their opinion as to which of the series of observations in groups D and E it would probably be advisable in the interests of astronomical science to publish.

8. It would appear to be very desirable that the publication of the Madras series of observations should be continued until the whole of these that are of value are placed in the hands of the scientific public before observational work on a large scale is resumed; and hence, further, that some arrangement be made by which Mr. Michie Smith's services might be retained in order that he may complete this work which he has commenced so vigorously and successfully.

Mr. Michie Smith's permanent appointment is Professor in the Christian College, Madras; and the arrangement by which he acts as Government Astronomer on leave without pay from that College ceases on the 30th June.

It will hence be necessary for Mr. Michie Smith to determine some time before that date (probably not later than the beginning of April) whether he will resign or return to his appointment in the College; and this will depend upon whether the Government of India is prepared before that time to offer him a permanent appointment in the Madras or Southern India Imperial Observatory.

9. With respect to the question of the desirability of establishing a Solar Physics Observatory in India, the Famine Commission urged strongly the continuance and extension of the work of solar observation in India. Thus, it is stated in paragraph 7 of the Famine Commission's Report that "on the whole, it is not possible for us, in the present state of knowledge, to say more than that the subject of the periodicity of fluctuations in the rainfall, as determined by the sun spot variation, is one deserving of careful investigation, and that it does not seem contrary to reasonable expectation that some relation should be established between the variations of the rainfall from year to year and those of the conditions of the sun's surface, on the heat derived from which, unquestionably, all terrestrial meteorological phenomena closely depend. For various reasons India is a country in which the investigation of this matter may be carried out with especial facility, and for this reason (though other grounds are not wanting) we would urge that as the expense of such researches would be small, the measures which have recently been taken by the Government of India to carry them out should be continued, *and even extended in the future.*"

This recommendation was, I believe, fully approved not only by the Government of India but by the Secretary of State; and it is in consequence of this recommendation that the work of solar observations has been continued in India, and that these observations are directed by the Solar Physics Committee in England. Nothing has occurred during the period since the close of the Famine Commission to weaken the force of their recommendation; and it is extremely desirable not only from scientific considerations, but also from the practical and economic standpoints of the Famine Commissioners that these observations should be not only continued, but should be carried out in a more complete and systematic manner than hitherto.

10. Three classes of observations are necessary—

- 1st, Photographic.
- 2nd, Spectroscopic.
- 3rd, Actinometric.

Photographic records are at present made at the Surveyor General's Office at Dehra Dun, but as that office will shortly be removed to Calcutta, it is necessary to find a new location for this work.

Spectroscopic observations have not yet been started, although the Secretary of State has requested they should be initiated. The delay is due to the difficulty in making arrangements for the proper performance of the work under present conditions.

Actinometric observations have been made at Leh and Mussoorie, and are at present taken at Simla. They have not been very satisfactory, partly in conse-

present time, I submit full proposals for the establishment of a Solar Physics Observatory and the continuance of the Madras Astronomical Observatory on a tentative footing.

4. If the Government of India are in a position to provide funds for the larger scheme, sketched in my memorandum, and which is apparently approved in its general outlines by the Solar Physics and Observatories Committees in England, full details can be easily prepared and submitted.

5. The following gives a brief statement of the work at present carried out in the Madras Observatory :—

Mr. Pogson during the period he was Government Astronomer (from 1861 to 1891, amassed an enormous number of observations, many of which were of great value. Little or nothing was done in the way of publishing the results of the observations until the last two or three years of his life. Before his death he gave full instructions and information respecting the unpublished observations to Mr. Michie Smith, and also recommended to the Madras Government the appointment of that gentleman as his successor, with a view to the continuation of the publication of the accumulated observations in the form he wished. Mr. Michie Smith was hence appointed temporarily, pending the settlement of the future of the Madras Observatory, and was specially instructed to devote himself to the publication of Mr. Pogson's series of observations. Hence, at the present time, the only systematic observational work carried on at the Madras Observatory is—

1st—Transit observations for the determination of time, and

2nd—Meteorological observations.

It may be noted that no magnetical observations have been taken for many years.

Satisfactory progress has been made during the past eighteen months in the work of publishing the series of observations.

Mr. Michie Smith has issued several volumes including the following :—

(1) Meteorological and Magnetical observations made at the Madras Observatory between the years 1861 and 1881.

(2) Telegraphic determination of the difference of longitude between Madras and eight other stations.

The following volumes containing results of observations made by Mr. Pogson are in course of preparation, and will, I am informed, be completed in a few months :—

A. Astronomical—

1. Separate results of 5,761 observations made with the new Meridian circle in 1862, 1863 and 1864; with the deduced catalogues for each year.
2. Separate Results of 7,651 observations made with the Meridian circle in 1865, 1866 and 1867; with the deduced catalogues for each year.

3. Separate Results of 5,867 observations made with the Meridian circle in 1868, 1869 and 1870; with the deduced catalogues for each year.
4. Separate Results of 5,603 observations made with the Meridian circle in 1871, 1872, and 1873; with the deduced catalogues for each year.
5. Separate Results of 4,639 observations made with the Meridian circle in 1874, 1875 and 1876; with the deduced catalogues for each year.
6. Separate Results of 9,637 observations made with the Meridian circle in 1877, 1878 and 1879; with the deduced catalogues for each year.
7. Separate Results of 9,267 observations made with the Meridian circle in 1880, 1881 and 1882; with the deduced catalogues for each year.
8. Separate Results of 4,052 observations made with the Meridian circle 1883 to 1887.
9. Catalogue of over 5,000 stars for the Epoch 1875, from observations made with the Meridian circle, between the years 1862 and 1887; under the superintendence of N. R. Pogson, C.I.E.

B. Magnetical—

10. Hourly Magnetical Observations made at the Madras Observatory between the years 1856 and 1860; under the superintendence of Majors W. S. Jacob, Bombay Engineers; W. K. Worster, Madras Artillery, and J. F. Tennant, Bengal Engineers.

C. Meteorological—

11. Hourly Meteorological Observations made at the Madras Observatory between the years 1856 and 1860; under the superintendence of Majors W. S. Jacob, Bombay Engineers; W. K. Worster, Madras Artillery, and J. F. Tennant, Bengal Engineers.

It will require about a year to finish these volumes, and thus complete the publication of the series of Mr. Pogson's observations with the Meridian circle.

6. In addition to these, there are the following series of observations taken by Mr. Pogson and lying at the Madras Observatory, some of which, if not the whole, should almost certainly be taken in hand and prepared for publication.

- D. (a) Observations of minor planets, comets and new variable stars and nebulae, furnishing 989 positions of 73 minor planets at 260 oppositions, 75 of 10 comets, those of such variable stars as are not observable with the Meridian circle, and of two new Nebulae in Ara and Phoenix, discovered by Miss E. Isis Pogson in 1876 and 1881.
- (b) Observations of the transit of Mercury, November 12, 1861; transit of Venus, December 8, 1874; six eclipses of the Sun; seven eclipses of the Moon; five occultations of planets; and numerous

This is derived from the following table:—

TABLE XVI.

1892.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	January to April.	May to September.	October to December.	Year.
MADRAS.																
No. of days on which cloud from																
0-2 { 20 hours ...	22	21	27	27	16	11	1	8	7	13	12	17	100	43	42	185
22 hours ...	...	...	...	...	11	9	1	8	4	11	14	13	...	33	35	...
3 and 4 { 20 hours ...	5	3	4	2	7	4	2	2	1	5	10	4	14	16	19	49
22 hours ...	...	...	...	...	11	4	2	3	2	8	9	8	...	22	25	...
5 and 6 { 20 hours ...	2	0	0	1	2	2	3	3	3	6	3	3	3	13	12	23
22 hours ...	...	...	...	...	4	3	3	2	5	3	3	6	...	17	12	...
7 and 8 { 20 hours ...	1	2	0	0	6	2	4	2	3	2	3	5	3	17	10	30
22 hours ...	...	...	...	...	2	3	0	1	4	4	0	3	...	10	7	...
9 and 10 { 20 hours ...	1	0	0	0	0	11	21	16	16	5	2	2	1	64	9	74
22 hours ...	...	...	...	...	3	11	25	17	15	5	4	1	...	71	10	(81)
KODAIKANAL.																
No. of days on which cloud from																
0-2 { 20 hours ...	9	14	30	10	13	7	2	2	11	6	16	...	63	35	...	...
22 hours ...	12	13	28	13	17	11	3	4	10	7	18	...	66	45	...	...
3 and 4 { 20 hours ...	3	7	0	4	2	1	2	2	3	1	3	...	14	10	...	...
22 hours ...	1	4	1	3	0	1	2	2	3	0	2	...	9	8	...	...
5 and 6 { 20 hours ...	1	3	0	2	4	3	4	3	3	3	3	...	6	17	...	...
22 hours ...	4	5	1	0	2	3	1	2	2	2	3	...	10	10	...	...
7 and 8 { 20 hours ...	7	2	0	4	2	5	2	3	3	3	2	...	13	15	...	...
22 hours ...	5	2	0	2	1	7	3	1	3	9	0	...	9	15	...	...
9 and 10 { 20 hours ...	11	3	1	10	10	14	21	21	10	18	6	...	25	76	...	...
22 hours ...	9	5	1	12	11	8	22	22	12	13	7	...	27	75	...	...
KOTAGIRI.																
No. of days on which cloud from																
0-2 { 20 hours ...	14	12	13	3	1	0	0	0	0	0	...	8	42	1	...	...
22 hours ...	17	19	24	3	7	3	2	1	0	1	...	11	63	13	...	...
3 and 4 { 20 hours ...	3	6	8	2	8	3	3	2	6	4	...	9	19	22	...	...
22 hours ...	8	2	4	8	6	3	7	6	11	8	...	9	21	33	...	...
5 and 6 { 20 hours ...	8	1	7	7	6	5	9	5	12	8	...	5	23	37	...	...
22 hours ...	0	2	2	1	3	9	8	3	9	6	...	6	5	32	...	...
7 and 8 { 20 hours ...	1	5	3	8	8	11	9	11	7	10	...	7	17	46	...	...
22 hours ...	1	0	...	8	4	10	6	10	7	9	...	2	9	37	...	...
9 and 10 { 20 hours ...	5	5	...	10	8	11	10	13	5	9	...	2	20	47	...	...
22 hours ...	5	6	1	10	11	5	8	11	3	7	...	3	22	38	...	...

MADRAS OBSERVATORY ; }
The 22nd January 1893. }

C. MICHIE SMITH.

No. 149-S.

FROM

THE METEOROLOGICAL REPORTER
TO THE GOVERNMENT OF INDIA.

TO

THE SECRETARY TO THE GOVERNMENT
OF INDIA, REVENUE AND AGRICULTURAL
DEPARTMENT.

Dated Simla, the 4th March 1893.

SIR,

I have the honor to acknowledge receipt of your letter No. 3576, dated 27th December 1892, forwarding a copy of a despatch from the Secretary of State, and requesting that after I have discussed the questions raised in that despatch with the Madras Government, I shall submit recommendations regarding them, with the report on the best site for the new Imperial Observatory, in which more especially I should state—

- (1) Whether I can recommend the establishment of a Solar Physics Observatory or the continuance of the Astronomical Observatory alone.
- (2) Whether in the former case I would recommend that Mr. Michie Smith should have superintendence of the Solar Physics observations.
- (3) What part of the work hitherto conducted at the Madras Astronomical Observatory should be continued there, if only a Solar Physics Observatory be maintained in its entirety.

2. The original proposal made in my review on the subject was to establish a combined Astronomical and Solar Physics Observatory on the best site in the hills of Southern India. The carrying out of this scheme in a complete and satisfactory manner would necessarily involve a large expenditure; and the Secretary of State hence suggests that if funds are not available for establishing a new complete observatory with two branches, the furtherance of Solar Physics would be the greater benefit to science, while astronomical requirements could for the time be met by the Madras Observatory.

3. As it is very probable the Government of India may not be disposed to sanction large expenditure on a scheme chiefly for scientific objects at the

TABLE XI.
Mean Cloud amount, Madras.

Month, 1892.	8 hours.	10 hours.	12 hours.	14 hours.	16 hours.	18 hours.	20 hours.	22 hours.	Mean.
January ...	4.0	4.5	...	4.3	4.0	...	2.0	...	3.8
February ...	2.4	3.6	...	2.3	1.9	...	1.4	...	2.3
March ...	1.6	2.1	...	1.6	1.6	...	1.2	...	1.6
April ...	4.3	3.6	2.9	2.8	2.4	3.1	1.0	3.2	2.9
May ...	4.4	3.3	2.5	2.8	3.5	3.7	3.1	3.7	3.4
June ...	...	...	...	...	...	...	...	...	...
July ...	7.7	6.5	7.4	7.7	7.9	8.2	8.3	8.6	7.8
August ...	8.0	6.9	7.1	7.6	7.6	7.6	6.5	6.7	7.3
September ...	7.0	6.4	6.5	6.6	7.4	7.5	6.8	7.1	6.9
October ...	5.0	5.0	6.0	5.0	5.0	5.0	4.0	4.0	4.9
November ...	5.0	5.0	6.0	5.0	5.0	4.0	4.0	4.0	4.8
December ...	...	5.0	...	...	5.0	...	...	...	...
Mean of year ...	...	...	...	...	...	...	...	...	...

TABLE XII.
Hours of Bright Sunshine.

1892.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	March and April.	May to September.	October to December.	March to December.	
KOTAGIRI, 6 to 7	...	...	7.1	1.7	0.8	2.3	1.7	0.5	0.2	—	0.2	1.2	0.8	2.5	4.7	2.2	9.4
7-8	...	...	20.5	22.5	15.5	17.4	11.3	4.4	3.7	8.3	7.4	17.8	17.1	38.0	45.1	42.3	125.4
8-9	...	...	27.2	30.2	23.1	20.3	14.9	8.6	9.8	13.7	17.2	23.6	23.6	53.3	67.2	65.4	186.9
9-10	...	...	24.8	29.6	24.1	21.7	16.0	10.2	10.8	16.4	18.9	23.6	23.7	53.7	75.7	63.2	197.6
10-11	...	...	24.0	27.3	25.1	23.0	13.2	10.4	12.1	17.3	17.8	26.0	23.5	52.4	76.2	67.3	195.9
11-noon	...	...	24.1	25.9	24.9	24.8	13.0	9.3	10.1	15.2	15.7	22.4	24.5	50.8	72.4	62.6	185.8
12-13	...	...	23.9	24.7	22.3	22.9	9.9	8.4	9.2	14.9	13.9	18.1	24.3	47.0	65.3	56.6	168.9
13-14	...	...	24.0	26.9	21.2	22.8	9.5	6.1	7.2	13.1	10.8	18.5	20.8	48.1	59.1	50.5	157.7
14-15	...	...	22.0	25.4	18.6	20.0	10.2	7.1	6.8	12.4	10.7	15.5	20.9	44.0	56.8	47.1	147.9
15-16	...	...	21.1	24.1	16.0	14.8	6.0	4.4	5.7	11.9	5.0	13.3	19.3	40.1	42.8	37.6	120.5
16-17	...	...	17.7	19.3	9.1	13.2	4.2	3.1	2.9	5.5	1.8	8.7	11.9	28.4	29.0	22.4	79.8
17-18	...	...	6.1	2.1	1.0	1.9	0.2	0.0	0.0	0.2	—	—	—	3.1	2.3	—	5.4
18-19	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
TOTAL	...	...	242.5	259.7	201.7	205.0	111.4	72.8	78.5	125.9	119.4	197.4	210.2	461.4	596.6	523.2	1581.2
KODAIKANAL 6-7	...	...	...	10.2	6.8	8.3	5.7	2.6	2.6	3.2	2.6	5.5	5.0	17.0	22.4	13.1	52.5
7-8	...	...	...	29.2	20.6	21.1	13.2	7.9	9.3	12.5	17.6	21.1	21.7	49.8	64.0	60.4	174.2
8-9	...	...	...	29.8	24.1	20.9	15.4	13.0	13.8	17.4	20.6	23.3	23.6	54.2	80.5	69.5	204.2
9-10	...	...	...	30.0	24.3	20.8	17.8	12.4	14.6	21.6	20.1	27.0	23.8	54.3	87.2	70.9	212.4
10-11	...	...	...	30.4	23.6	23.5	15.5	12.1	13.4	21.1	18.2	22.4	23.3	54.0	85.6	64.3	203.9
11-noon	...	...	...	29.3	23.1	22.7	13.2	10.9	8.9	18.1	15.6	20.3	22.4	52.4	73.8	58.3	184.5
12-13	...	...	...	26.2	22.0	21.2	7.7	10.3	7.6	13.6	8.6	18.2	21.7	48.2	60.5	48.5	157.2
13-14	...	...	...	25.1	19.0	19.1	7.4	6.2	4.6	10.9	7.8	16.5	20.4	44.1	48.2	45.0	137.3
14-15	...	...	...	23.1	16.4	13.3	6.4	5.3	3.4	6.1	6.3	13.5	19.1	39.5	34.7	33.9	113.1
15-16	...	...	...	21.8	13.5	12.0	3.7	3.8	2.4	5.7	6.9	12.5	15.4	35.3	27.7	35.1	98.1
16-17	...	...	...	21.9	11.0	9.4	3.5	1.4	2.1	3.3	5.2	7.3	11.7	32.9	19.7	24.2	76.8
17-18	...	...	...	7.7	2.4	4.3	1.7	0.0	0.3	0.8	0.2	0.2	1.7	10.1	7.1	2.1	19.3
18-19	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
TOTAL	...	...	...	284.7	207.1	166.6	111.2	85.1	83.0	134.3	129.7	190.8	209.8	491.5	611.4	530.3	1633.5
MADRAS 6 to 7	...	2.3	1.5	0.8	5.1	9.2	6.5	2.9	2.6	4.3	3.2	1.2	0.6	5.9	25.5	5.0	36.4
7-8	...	20.8	22.5	19.9	19.8	23.8	14.7	6.4	7.0	9.6	13.8	15.0	16.1	39.7	63.8	44.9	145.4
8-9	...	25.5	27.6	29.1	24.3	27.9	19.4	8.9	12.2	12.7	20.7	21.7	22.8	53.4	78.1	65.2	156.7

TABLE XII—contd.

Hours of Bright Sunshine.

1892.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	March and April.	May to September.	October to December.	March to December.
9-10	29.1	25.2	30.0	25.6	27.8	17.0	13.5	14.8	14.4	22.1	23.7	23.5	55.0	87.5	67.3	212.4
10-11	26.7	23.5	30.5	26.5	23.0	18.8	16.4	16.4	17.9	20.6	23.4	24.2	57.0	97.9	68.2	223.1
11-12	26.4	23.6	30.8	26.2	27.7	20.0	16.0	18.5	18.5	21.1	23.5	24.1	57.0	101.9	67.7	226.6
12-13	27.9	28.9	30.7	25.0	28.6	20.4	16.3	16.8	18.2	22.4	20.7	25.2	56.7	100.2	69.3	225.3
13-14	28.8	28.9	31.0	27.0	27.9	20.4	15.0	14.1	14.5	22.2	23.5	25.0	58.0	91.9	71.3	221.2
14-15	27.4	28.6	31.0	26.7	28.4	21.4	12.8	13.3	10.6	13.6	22.8	24.7	57.7	85.5	65.1	210.3
15-16	25.0	28.0	27.9	27.3	26.6	19.8	10.2	11.4	11.3	18.5	21.0	23.9	57.2	77.3	63.4	199.9
16-17	18.0	27.0	25.0	20.0	23.2	16.3	6.9	9.6	9.6	17.5	18.2	19.1	45.9	63.6	54.7	165.2
17-18	1.5	18.4	9.3	5.5	8.9	8.2	0.7	4.0	3.5	5.7	3.9	0.5	14.8	25.3	9.0	50.0
TOTAL	250.4	294.7	298.0	263.9	288.0	192.2	127.3	141.0	145.1	206.4	217.6	231.0	553.9	900.6	655.0	2114.5

TABLE XIII.

Equivalent number of hours of full sunshine.

Madras	...	200.1	204.7	163.6	171.3	246.0	151.7	94.3	91.8	90.9	128.9	140.2	142.7	334.9	674.7	411.9	1421.5
Kodaikanal	...	...	[171.9]	237.1	157.2	128.6	55.4	65.6	63.9	111.3	108.6	139.0	165.1	394.3	424.8	413.2	1232.4
Kotagiri	...	*[141.6]	154.6	164.9	150.8	141.4	60.1	48.1	53.6	83.7	82.3	145.8	142.4	315.7	321.9	370.5	1078.1

TABLE XIV.

Mean Time of first recorded sunshine.

Madras	...	7.2-h	7.1	7.3	7.3	6.6	7.5	8.8	8.1	7.8	7.6	7.8	7.4
Kodaikanal	...	...	[6.8]	6.7	6.9	6.8	7.1	8.2	7.1	7.5	7.3	7.1	7.1
Kotagiri	...	*[6.7]	7.0	7.1	7.5	7.5	7.7	8.2	8.2	7.8	8.0	7.2	7.4

TABLE XV.

Mean Time of last recorded sunshine.

Madras	...	16.7	17.7	17.1	16.9	17.3	17.1	15.7	15.7	15.3	16.6	16.5	16.7
Kodaikanal	...	...	[16.8]	17.0	16.3	15.7	14.3	13.1	14.6	14.8	14.6	15.4	16.1
Kotagiri	...	[16.8]	16.3	16.8	15.9	16.1	14.8	14.7	14.9	16.1	15.2	16.0	16.1

TABLE XVI.

Relative merits deduced from Cloud Observations at 20 hours and 22 hours.
(A weight of 10 is given to days having not more than $\frac{2}{10}$ of cloud, of 6 to days having from $\frac{3}{10}$ to $\frac{4}{10}$ and of 2 to days having from $\frac{5}{10}$ to $\frac{6}{10}$ of cloud.)

1892.		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	January to April.	May to September.	October to December.	Year.
Madras	...	254	253	254	284	195	107	23	100	72	163	193	195	1090	502	536	2148
Kodaikanal	...	134	176	291	159	162	102	42	47	123	73	291	...	763	431	...	...
Kotagiri	..	195	182	230	68	91	65	57	37	72	55	...	160	676	322	...	...

* [] Incomplete.

TABLE VII.

Mean number of rainy days.

(A rainy day being a day on which a tenth of an inch of rain or upwards falls).

Month.						Madras.	Kodaikanal.	Kotagiri.
January	...	...	...	...	...	1'4	1'0	1'8
February	...	...	...	...	...	0'1	0'5	0'5
March	...	...	...	...	...	0'6	3'3	2'3
April	...	...	...	...	...	0'3	5'8	4'8
May	...	...	...	...	...	1'5	10'8	10'5
June	...	...	...	...	...	4'7	9'0	7'8
July	...	...	...	...	...	6'9	8'5	9'8
August	...	...	...	...	...	8'2	12'0	8'8
September	...	...	...	...	...	7'1	13'8	11'0
October	...	...	...	...	...	10'0	15'0	16'3
November	...	...	...	...	...	11'0	10'5	9'8
December	...	...	...	...	...	5'2	8'5	6'3
Total of year	...	...	...	...	...	57'0	98'7	89'7

TABLE VIII.

Mean daily amount of wind.

Month, 1892.						Madras.	Kodaikanal.	Kotagiri.
						Miles.	Miles.	Miles.
January	...	...	...	...	...	163	?	134
February	...	...	...	...	...	138	?	127
March	...	...	...	...	...	163	179	129
April	..	...	...	...	...	189	147	148
May	...	...	...	...	...	226	236	155
June	...	...	...	...	...	176	160	151
July	...	...	...	...	...	155	203	126
August	...	...	...	...	...	110	124	...
September	...	...	...	...	...	118	234	...
October	...	...	...	...	...	116	182	...
November	...	...	...	...	...	165	202	...
December...	...	...	...	...	...	159	175	81
Mean of year	...	...	...	...	...	157	184	...

TABLE IX.

Mean cloud amount, Kodaikanal.

Month, 1892.				8 hours.	10 hours.	12 hours.	14 hours.	16 hours.	18 hours.	20 hours.	22 hours.	Mean.
January	...	...	...	4'4	5'3	5'7	6'3	6'7	7'0	6'0	4'8	5'8
February	...	...	...	1'1	1'8	3'3	4'1	5'7	3'9	3'2	3'8	3'4
March	...	...	...	0'6	0'8	2'6	3'4	2'9	1'8	0'7	0'7	1'7
April	...	...	...	2'7	3'0	4'5	5'4	5'9	5'6	5'3	4'9	4'7
May	...	...	...	4'2	4'4	4'7	6'2	7'5	6'1	4'7	4'3	5'3
June	...	...	...	5'5	6'2	9'0	8'9	8'5	8'2	6'6	5'2	7'3
July	...	...	...	7'9	8'7	8'9	9'6	9'3	9'4	8'1	8'1	8'8
August	...	...	...	7'6	8'0	9'2	9'2	9'2	8'6	8'2	7'8	8'5
September	...	...	...	6'3	6'7	8'1	9'0	8'8	7'2	5'1	5'3	7'1
October	...	...	...	5'1	6'6	8'1	8'6	8'4	8'4	7'1	6'5	7'4
November	...	...	...	3'5	5'3	7'4	7'3	8'4	7'5	3'5	3'1	5'8
December	...	...	...	4'0	4'1	6'0	6'3	6'7	6'0	4'4	4'3	5'2
Mean of year	...	...	...	4'4	5'1	6'5	7'0	7'3	6'6	5'2	5'0	5'9

TABLE X.

Mean cloud amount, Kotagiri.

[illegible]

TABLE III.

Mean Humidity.

Month, 1892.					Madras.	Kodaikanal.	Kotagiri.	Simla (normal).
					%	%	%	%
January	...	...	...	...	76	72	69	60
February	...	...	...	...	76	64	62	56
March	...	...	...	...	75	47	52	52
April	...	...	...	...	76	67	69	47
May	...	...	...	...	61	70	73	48
June	...	...	...	...	72	79	82	63
July	...	...	...	...	72	80	80	89
August	...	...	...	...	80	83	...	91
September	...	...	...	...	76	71	...	78
October	...	...	...	...	82	81	...	52
November	...	...	...	...	78	80	...	48
December	...	...	...	...	80	68	72	45
Mean of year	...	...	...	...	75	72	...	61

TABLE IV.

Monthly Rainfall.

Actual, 1892.

Month, 1892.					Madras.	Kodaikanal.	Kotagiri.
					Inches.	Inches.	Inches.
January	...	...	...	...	0.13	0.15	0.01
February	...	...	...	...	Nil.	0.69	Nil.
March	...	...	...	...	Nil.	0.38	0.09
April	...	...	...	...	6.69	8.84	8.29
May	...	...	...	...	Nil.	4.33	5.38
June	...	...	...	...	4.02	8.71	6.11
July	...	...	...	...	7.82	3.65	4.90
August	...	...	...	...	10.79	7.01	6.41
September	...	...	...	...	6.29	1.75	3.40
October	...	...	...	...	6.60	9.54	14.58
November	...	...	...	...	0.96	0.64	2.60
December	...	...	...	...	4.74	1.84	3.25
Total of year	...	...	...	...	42.04	47.53	55.02

TABLE V.

Actual number of rainy days on which 0.01 inch or upwards fell.

Month, 1892.					Madras.	Kodaikanal.	Kotagiri.
January	...	...	...	...	2	4	1
February	...	...	...	...	0	5	0
March	...	...	...	...	0	3	2
April	...	...	...	...	2	16	16
May	...	...	...	...	0	19	15
June	...	...	...	...	11	19	19
July	...	...	...	...	21	21	15
August	...	...	...	...	19	24	13
September	...	...	...	...	14	8	7
October	...	...	...	...	11	21	18
November	...	...	...	...	2	7	4
December	...	...	...	...	6	8	5
Total of year	...	...	...	...	88	155	115

TABLE VI.

Mean Monthly Rainfall.

Month.					Madras.	Kodaikanal.	Kotagiri.
					Inches.	Inches.	Inches.
January	...	...	...	...	0.94	0.55	0.53
February	...	...	...	...	0.29	0.63	0.20
March	...	...	...	...	0.41	3.02	1.63
April	...	...	...	...	0.63	6.14	3.36
May	...	...	...	...	2.21	4.86	7.41
June	...	...	...	...	2.07	3.90	2.43
July	...	...	...	...	3.78	4.92	4.58
August	...	...	...	...	4.48	6.39	4.33
September	...	...	...	...	4.75	6.70	6.99
October	...	...	...	...	10.99	10.87	10.22
November	...	...	...	...	13.75	5.59	6.93
December	...	...	...	...	5.24	7.39	4.16
Total of year	...	...	...	...	49.54	60.96	52.77

- (3) There is as a rule less cloud from sunrise up to 10 A.M. or 11 A.M., and also after 5 P.M. or 6 P.M., the most important periods of the day for astronomical and solar observations.
- (4) There is less cloud during nearly the whole day in the clearest and finest months of the year, *i.e.*, during the season when probably the best work of the year would be done.
- (5) The atmosphere appears to be as a general rule purer, clearer, and less disturbed during the morning up to 10 A.M., the important period of the day for solar observation.
- (6) Finally, a far more satisfactory site for the observatory for the object in hand could be obtained in the neighbourhood of Kodaikanal than at Kotagiri.

I have the honor to be,

SIR,

Your most obedient Servant,

JOHN ELIOT,

Meteorological Reporter to the Government of India.

APPENDIX I.

TABLE I.
Mean daily Temperature, Mean of Max. and Min.

Month, 1892.	Madras.	Kodaikanal.	Kotagiri.	Simla (mean of year.)
	°	°	°	
January	75.7	54.5	55.3	43.8
February	77.5	57.9	59.3	44.3
March	81.2	60.9	64.0	53.6
April	85.1	61.9	64.8	61.8
May	89.0	62.2	64.1	67.0
June	85.5	60.3	62.3	69.4
July	84.2	58.9	61.1	66.4
August	81.7	58.0	...	65.1
September	82.1	58.4	...	64.3
October	80.6	57.2	...	59.5
November	77.5	57.5	...	52.1
December	75.4	54.1	57.5	48.2
Mean of year	81.4	58.5	...	58.0

TABLE II.
Mean daily range of Temperature.

Month, 1892.	Madras.	Kodaikanal.	Kotagiri.	Simla (mean of year.)
	°	°	°	
January	17.1	15.6	16.6	14.8
February	19.1	16.8	18.9	16.3
March	19.2	16.7	21.2	17.4
April	15.1	16.3	18.8	19.2
May	18.2	15.0	16.6	19.3
June	17.2	13.4	13.6	17.7
July	15.4	12.2	12.4	11.5
August	14.5	11.5	...	10.6
September	15.2	13.8	...	14.1
October	14.7	12.0	...	16.7
November	16.2	12.5	...	16.8
December	16.1	14.9	17.8	16.4
Mean of year	16.5	14.2	...	15.9

The following are the Madras abnormals for *percentage of clear sky* in 1892:—

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
+ 2	+ 7	+ 9	+ 3	+ 5	+ 6	— 4	— 5	— 4	+ 8	+ 13	+ 7

Number of days on which the sun could have been photographed.

An attempt has been made to determine from the sunshine recorder slips the number of days on which the sun could have been photographed at each station. The estimate is made by rejecting those days on which the sunshine did not reach an intensity of about 7 for not less than 20 minutes. The following is the result:—

Table showing number of days on which it would have been possible to photograph the sun.

	MADRAS.			KOTAGIRI.			KODAIKANAL.		
	Neither forenoon nor afternoon.	Forenoon, but not afternoon.	Afternoon, but not forenoon.	Neither forenoon nor afternoon.	Forenoon, but not afternoon.	Afternoon, but not forenoon.	Neither forenoon nor afternoon.	Forenoon, but not afternoon.	Afternoon, but not forenoon.
March and April ...	1 + 2?	1 + 1?	1	1	2	1	2	3	3
May to September ...	23 + 2?	11 + 1?	9 + 2?	23 + 5?	39 + 6?	20 + 3?	12 + 2?	40 + 4?	9 + 3?
October to December	5	4 + 1?	6 + 2?	3 + 3?	7 + 4?	3	6	12 + 4?	2 + 1?
March to December...	29 + 4?	16 + 3?	16 + 4?	27 + 8?	48 + 10?	24 + 3?	20 + 2?	55 + 8?	14 + 4?

NOTE.—4? means there were 4 days on which a photograph could probably, but not certainly, have been got.

The number of days on which a photograph could not have been got are few at all the places, but Kodaikanal is sensibly better than either of the other two.

The general result appears to me to be that, entirely apart from the special considerations which I have brought forward in my report on these stations (G. O. 16th September 1892, No. 648), Kodaikanal is for solar work decidedly superior to Kotagiri. Its superiority over Madras for this special work is less clear, but I believe that the much greater transparency of the air, especially in the forenoons, and the greater ease with which the work can be carried on, more than counterbalance the smaller total amount of sunshine. For actinometric work Madras is, of course, out of the question.

Relative merits of the stations as deduced from cloud observations at 20 hrs. and 22 hrs.

This is shown graphically in Figure 17. Unfortunately the data for November and December are incomplete. The estimate is got by giving a weight of 10 to all nights on which the cloud proportion did not exceed $\frac{2}{10}$, of 6 to nights with $\frac{3}{10}$ or $\frac{4}{10}$, and of 2 to nights with $\frac{5}{10}$ to $\frac{6}{10}$. From this diagram

Madras appears best, except in March, July, September, and November; but this is really far from being the case, as on very many of the nearly cloudless nights there is a thick haze which is not found at the hill stations. Kodaikanal is superior to Kotagiri, except in February and July."

(7) *Transparency of the atmosphere.*—With respect to the general clearness and purity of the atmosphere, conditions of great importance for photographing the details of the solar disc, and for actinometric work, it was not possible to obtain any observations from the observers. Mr. Michie Smith and Miss Pogson, who have both visited the stations of Kodaikanal and Kotagiri, speak most favourably of the clearness and transparency of the atmosphere at these hill stations as compared with Madras. Kodaikanal appears also to be superior to Kotagiri in this respect. Thus Mr. Michie Smith in his report says:—

"The general results at which I have arrived from these observations as regards the relative merits of Kodaikanal and Kotagiri as a site for an observatory is that Kodaikanal is by far the better situation of the two. Whether or not this has been absolutely proved by the observations detailed above depends to a certain extent on the further consideration of whether the atmospheric conditions at the time when I was observing were fairly characteristic of the Kotagiri climate. Personally, I have not the least doubt that the conclusion is the correct one, for the general impression of the superiority of Kodaikanal very strongly forced itself upon me while I was observing at Kotagiri; and I can affirm without hesitation that the best night while I was at Kotagiri, was inferior to the worst observing night at Kodaikanal. Having already expressed an opinion in favour of Kodaikanal, I took particular care that full justice was done to Kotagiri, and took every possible opportunity of getting the most favourable observations. The inferiority was particularly marked in the solar observations and in the observations of the finer details of nebulae."

* * * * *

"In both of these researches the remarkable steadiness and transparency of the air at Kodaikanal would be an enormous advantage, and I believe that more good work could be done on a dozen clear nights there than on fifty clear nights at Madras. Solar observations could be carried on with at least equal success and with much greater comfort to the observer."

It is hardly necessary to state that Madras is for various reasons unfitted as a site for a Solar Physics Observatory.

The meteorological observations taken at Kodaikanal and Kotagiri establish, I think, fully that Kodaikanal is superior in almost every respect to Kotagiri.

- (1) Temperature is more uniform, whether the diurnal or annual changes be considered.
- (2) The mean temperature ($58\frac{1}{2}^{\circ}$) is practically that best suited for the observational and laboratory work which would be carried on in Solar Physics Observatory, and is approximately that of the standard temperature assumed in much laboratory work in Europe (*viz.*, 60° or 62°). It is about 7° above the mean temperature of London.

Hence the general conclusion, that during the four months of least cloud there is much less cloud during nearly the whole day at Kodaikanal than at Kotagiri, and during the remainder of the year there is usually less cloud in the morning up to 10 A.M., and again in the evening after 5 or 6 P.M. Cloud forms more largely at Kodaikanal during the period of greatest convective action and air motion from about 10 A.M. to 4 P.M. As a rule, the photographic and probably the spectroscopic work would be done in the morning when the air would be most free from dust and least disturbed. It is hence apparent that the atmospheric conditions for the solar physics observations, so far as measured by the absence of cloud at the most important period of the day for the work, are more satisfactory at Kodaikanal than at Kotagiri.

A comparison of the cloud curves, Plate I, with those of the amount of sunshine, Plate II, show a close correspondence, the only difference being that the amount of sunshine at different hours of the day varies to a less extent than the amount of cloud. It is not necessary to endeavour to estimate to what extent the cloud estimates of the observatory at Kodaikanal would have to be reduced in order to represent fairly the cloud on the open plateau at a distance of 2 or 3 miles from the edge, as the data show sufficiently the superiority of Kodaikanal to Kotagiri.

(6) *Sunshine*.—The following statement of the results of the sunshine observations at the hill stations of Madras, Kodaikanal, and Kotagiri was drawn up by Mr. Michie Smith. It deals with the questions exhaustively, and is hence given in full. The data will be found in Tables XII, XIII, XIV, XV and XVI of the Appendix to the report, and all the more important results are charted on Plate II accompanying this report.

“The following points have to be taken into account with reference to all that follows :—

- (1) Solar time is used throughout, XII on the card having been placed at the meridian mark of the instrument, and no correction having been applied for equation of time. Neither has any correction been applied for scale errors at different times of the year.
- (2) The observations made at Madras are not strictly comparable with those made at the two other stations. The Madras instrument is a Whipple-Casella recorder, of which the sphere is of remarkably clear white glass, while the metal card holder is moveable and only about one inch wide. The other two instruments are of the old pattern, with fixed broad card holder and glass spheres which are distinctly coloured. Until the instruments have been compared side by side, it is impossible to say to what extent they differ; but there can be little doubt that the Madras instrument will record somewhat fainter sunshine than the others.

Hourly amounts of sunshine.

Figures 1—10, Plate II, show graphically the amounts of sunshine recorded in each hour from sunrise to sunset for each month from March to December. The records for the first three months of the year are incomplete. Figures 11—13 show the sunshine for each hour for the periods March—April, May—September,

and October—December. The first feature which calls for attention in these diagrams is the excess of sunshine at Madras over both the hill stations; and though part of this may be accounted for by the difference of instruments, it is evident that this explanation will not account for any large proportion of it. The excess is mainly in the afternoon, and is due to the well-known tendency for clouds to form on the hills in the afternoons. The total amount of sunshine recorded at Kodaikanal is considerably in excess (52 hours) of the total amount recorded at Kotagiri; and the hourly distribution at the two stations is very different. In every month Kodaikanal has more sunshine in the forenoon and less in the afternoon than Kotagiri. From sunrise till about noon Kodaikanal is the clearer station; then from noon till about 5 P.M. Kotagiri is clearer, but after 5 P.M. Kodaikanal seems again to clear, and has more sunshine than Kotagiri between 5 and 6 P.M. This may be due to difference in the exposure of the instruments; but I think not, as the cloud observations at 20 hours and 22 hours show Kodaikanal to have a clearer atmosphere than Kotagiri at these hours. For the ten months the excess of forenoon sunshine at Kodaikanal over Kotagiri is 131 hours. This is a point of very great importance in favour of Kodaikanal, because it is in the forenoons that all the best solar work can be done at a hill station. For most months the early morning is brighter at Kodaikanal even than at Madras. In the diagrams 1 to 13 all sunshine has been treated alike so long as it was able to leave a burned trace on the card, but evidently this is not quite satisfactory; and an attempt has been made in Figure 14 to take into account the intensity as well as the duration. In this diagram the difference between the two kinds of instruments used must not be forgotten. The table from which the diagram is drawn is prepared by multiplying the number of hours of sunshine for each day by a number (1—10) representing the mean intensity for the day, and dividing by 10 to get the equivalent “full sunshine”. In March, September, and December, Kodaikanal is the best of all the stations, but for the other months Madras leads. Kotagiri is below Kodaikanal in all months except May, June, and November, when it is slightly better. Figures 15 and 16 show the relative times of the mean first and last recorded sunshine at each of the stations for each month. The chief points to note here are that, except in July, when it is the same, the sun appears much earlier at Kodaikanal than at Kotagiri, and that, except in May, it appears sooner than at Madras, indicating probably clearer nights at Kodaikanal. As regards last sunshine, Kotagiri is better off than Kodaikanal, except in March, April, and December. At first sight this seems contradictory to the statement made above, that there is more sunshine between 5 and 6 P.M. at Kodaikanal than at Kotagiri; but really it is not so, since the whole of the recorded sunshine between 5 and 6 P.M. was given on a few days in each month. Part of the inferiority of Kodaikanal over Kotagiri in the afternoons is due to the position of the observatory, which is so situated that it is frequently in mist, while the places farther west are quite clear. This statement is made from the results of actual observation and is not a mere surmise. Still, I have no doubt that Kotagiri is really somewhat clearer than Kodaikanal in the afternoons.

In concluding these remarks, it may not be amiss to point out that at Kodaikanal the weather was far from normal last year (1892). According to the unanimous opinion of those who know the place well, and with whom I have had an opportunity of speaking, the summer months were much more cloudy than usual, while, on the other hand, October and November were much brighter than usual.

more especially actinometric work. With respect to the latter, it should also be kept in mind that it involves much exposure to the sun, and, as Mr. Michie Smith points out—"Solar observations at Madras in the hot weather are carried on with great difficulty, if not with actual danger, to the health of the observer; whereas at a hill station, though the direct solar radiation may be more intense, the coolness of the air renders the work comparatively pleasant as soon as the observer has once got thoroughly sunburnt."

Rainfall.—The actual monthly rainfall and the number of rainy days of the three stations, Madras, Kotagiri, and Kodaikanal, are given in Tables IV and V. Normal rainfall data for these stations are also available, and are given in Tables VI and VII. A comparison of the actuals of 1892 with the normals show that the rainfall at the hill stations in 1892 was very abnormal, the number of rainy days being very largely in excess at Kodaikanal as compared with the excess at Kotagiri. This was apparently not due to larger rainfall than usual, as the total rainfall of the year was considerably below the normal at Kodaikanal, whilst it was slightly in excess at Kotagiri. This may be possibly due to the position of the observatory at Kodaikanal, which is close to the edge of the precipice facing the plains to the south, whilst the normals are for the revenue raingauge station which is at some distance from the cliff. This exaggeration of the number of rainy days due to the peculiar position of the observatory is of importance, as it is almost certain that the same condition would exaggerate the cloud amount; and hence it is very probable that the cloud amounts obtained for the observatory are larger than would have been obtained if the observatory had been located on the open rolling ground, away from the edge of the plateau on which Kotagiri is situated, and where, for various reasons, it was not possible to locate the temporary observatory.

The chief facts of the normal rainfall data are the following:—

Kodaikanal receives slightly more rain than Kotagiri (about twelve per cent. more). This distribution is dependent on the fact that the Nilgiris are some distance to the north of the Palnis, and hence slightly differently situated relative to the rain-bearing currents of the south-west monsoon from the West Coast, and those from the Coromandel Coast during the retreating south-west monsoon. Kodaikanal obtains more rain in March and April and less in May and November, and more in August and December. The differences in the remaining months are small and of little importance.

Table VII of the mean number of rainy days furnishes similar evidence. The number of rainy days at Kodaikanal is 98.7, or 9.0 in excess of Kotagiri, and hence almost exactly 10 per cent. in excess. Kodaikanal has more rainy days in March, April, June, August, September, and December, and less in July and October, than Kotagiri.

The number of rainy days is, as might be expected, considerably greater at these hill stations than at Madras. The mean daily rainfall per rainy day at Kodaikanal is .618 inch and at Kotagiri .588 inch.

(4) *Humidity.*—The observations indicate that there is no marked difference between the humidity conditions of Kodaikanal and Kotagiri. Kodaikanal appears to be slightly drier than Kotagiri, but the difference is too small to be of

any importance. Both stations appear to be much subject to mists and fogs. Hence an attempt was made to measure the amount of mist; but the observations appear to be of little value, as in many instances they conflict with the evidence of the sunshine recorder. The fogs are chiefly due to the forced ascensional movement of the air, and hence form most largely during the period when convective action is most vigorous, *i.e.*, from about 10 A.M. to 4 P.M.

(5) *Cloud.*—In order to test this important factor in the value of a station for astronomical purposes, observations of the amount and kind of cloud were taken every two hours between 8 A.M. and 10 P.M. The observers at Kotagiri and Kodaikanal were both trained by Miss Pogson, and no attempt was made to alter the standards of their eye estimates during the year. The observations appear on the whole to have been carefully taken, and may be accepted as fairly representing the cloud conditions of the two observatories. As already noted in the rainfall section, it is probable the cloud amount of Kodaikanal is exaggerated to some extent from the position of the observatory.

The monthly means of amount of cloud are given in Tables IX, X and XI of the Appendix and are plotted in Fig. 1 to 13 of Plate I. The monthly means show that there is less cloud at Kodaikanal from February to June, and that there is more cloud during the remainder of the year. On the average of the whole year, there is practically no difference.

The curves, Figure 1 to 12, Plate I, present the following features:—

- (1) The cloud curves of January are almost identical in form, and show that there is more cloud throughout the whole day at Kodaikanal than at Kotagiri.
- (2) During the dry and hot weather months from February to May the amount of cloud is considerably less at Kodaikanal. March is especially free from cloud at that station. In all these months, but more especially in February and May, cloud forms to a much larger extent in the hottest part of the day at Kodaikanal than at Kotagiri. Hence, although the cloud amount is much less at the former station during the morning up to 10 or 11 A.M., and again in the afternoon from about 3 or 4 P.M., it is frequently greater during the intervening interval from 10 A.M. to 3 P.M.
- (3) During the south-west monsoon period from June to September the cloud amount is large at both stations, but is larger to a moderate extent at Kodaikanal than Kotagiri. It is, however, noteworthy that during the greater part of this period (very notably in June and September) there is less cloud at Kotagiri in the morning up to 9 or 10 A.M., and again in the afternoon and evening after 5 P.M.
- (4) During the months of October, November, and December, the period of the retreating south-west monsoon currents, the cloud amount is nearly as large as during the preceding four months. It is also slightly larger on the average of the whole day at Kodaikanal than at Kotagiri; but, as in the preceding period, the excess at Kodaikanal occurs chiefly between 10 A.M. and 4 P.M. or 5 P.M. It is in all the months less cloudy at Kodaikanal up to 10 A.M. and also after 8 P.M.

It would hence be much easier to find an almost perfect location for a Solar Physics Observatory at Kodaikanal than at Kotagiri. Mr. Michie Smith in his report (paragraph 5) discusses this point, and he is fully qualified to speak on it from his acquaintance with the topography of both districts. He says the formation of the hills at Kotagiri is much less favourable for observational work than the formation about Kodaikanal. Kotagiri lies in a basin, surrounded by hills rising to a moderate height on all sides. At Kodaikanal, on the other hand, there is a large plateau rising in the centre, and this situation seems to be exactly what would be desired on general principles as the site of an observatory. He also adds that he endeavoured to find an equally favourable site in the Nilgiris hills, but failed.

It may hence be fairly concluded that Kodaikanal offers an admirably exposed site for such an observatory, and that Kotagiri does not.

In order to test the atmospheric conditions of these two hill stations, and determine which would be most suitable for the Solar Physics Observatory, temporary meteorological observatories were established, and regular observations taken from January 1892 up to March 1893. The following observations were taken daily :—

- (1) Temperature at 8, 10 and 16 hrs.
- (2) Humidity at 8, 10 and 16 hrs.
- (3) Wind direction and amount at 8, 10 and 16 hrs.
- (4) Cloud amount and kind at two-hourly intervals from 8 A.M. to 10 P.M.
- (5) Amount of sunshine as measured by sunshine recorders.
- (6) Special mist observations.
- (7) Solar and terrestrial radiation observations.

The monthly means of these observations and the corresponding means for Madras are given in the tables in the appendix to this letter. They are also charted in Plates I and II in such a manner as to show the relative merits of the stations for the more important elements of observation. The following gives a verbal summary of the more important features for a comparison of the relative merits of the stations :—

(2) *Temperature*.—Table I, Appendix I, gives the mean temperature of each month of 1892 at Madras, Kodaikanal, and Kotagiri, and the normal monthly temperature of Simla for comparison with the southern hill stations. The mean monthly temperature of Kodaikanal in 1892 ranged between 54.1° in December and 62.2° in May, thus giving an annual variation of only 8.1° . The mean monthly temperature at Kotagiri varied from 55.3° (in January) to 64.8° (in April), thus giving an annual range of 9.5° . The mean temperature of the year at Kodaikanal was 58.5° , agreeing almost exactly with that of Simla (58.0°). The range of the mean monthly temperature at Kodaikanal (*viz.* 8.1°) was, however, less than a third of the normal range at Simla (25.6°). Another important feature of the temperature conditions is the diurnal range. Table II gives comparative data for the same stations. It may be noted that the annual range of temperature in India depends chiefly upon the varying intensity of solar radiation at the earth's surface, and hence is small in Southern India and large in Upper India.

On the other hand, the diurnal range, especially at the hill stations, depends largely upon the convective actions and currents set up by the changes in that intensity during the day with the varying altitude of the sun; and hence the differences in this feature are comparatively small between hill stations in Southern and Northern India. The mean monthly diurnal range of temperature in 1892 at Kodaikanal varied from 11.5° to 16.8° , and averaged 14.2° ; at Kotagiri it varied from 12.4° to 21.2° , and averaged 17.0° ; whilst at Simla it ranges normally between 10.6° and 19.3° , and averages 15.9° . Hence the diurnal mean range of temperature is slightly less at Kodaikanal than at Simla and also at Kotagiri. The mean daily range of temperature at Madras is somewhat less than at the hill stations. Hence the characteristic features of the air temperature at the southern hill stations are :—

- (1) Moderate temperature.
- (2) Very small range or variation of temperature during the year.
- (3) Moderate diurnal range of temperature.

In each of these respects Kodaikanal is superior to Kotagiri, its temperature being on the average of the year about 2° lower, and the annual range about 1° less, and the diurnal range about 2° less.

Hence, so far as uniform and moderate temperature conditions are concerned, Kodaikanal is superior to Kotagiri.

(3) *Solar and Terrestrial Radiation Observations*.—Means of these observations have not been included in the tables, Appendix I, as they show practically no difference between the hill stations. The observations for the months May to October give a mean difference of 62.4° between the corrected mean maximum and the corrected mean maximum of a solar radiation thermometer. The corresponding mean difference of the same period for Kotagiri was 62.5° , practically identical with the former. Similarly, the difference between the grass radiation thermometer and minimum in shade for the same period at Kodaikanal was 5.5° and at Kotagiri 5.8° .

These observations were not taken at Madras. Normal means for three stations similarly situated to Madras are given below for the same period of the year :—

Stations.				Difference solar thermometer and maximum.	Difference grass radiation thermometer and minimum.
Port Blair	...	...	...	51.4	3.7
Bombay	...	...	...	52.8	3.6
Negapatam	...	...	...	53.3	4.0

It may hence be assumed that at Madras the corresponding means would be very approximately 52.0° and 4° , or $\frac{1}{6}$ th and $\frac{1}{4}$ th respectively less than the means for the hill stations. These differences measure roughly the superiority of the hill stations as compared with Madras for all solar physics work, but

No. 147-S.

FROM

THE METEOROLOGICAL REPORTER
TO THE GOVERNMENT OF INDIA,

TO

THE SECRETARY TO THE GOVERNMENT OF INDIA, REVENUE AND AGRICULTURAL DEPARTMENT.

Simla, the 1st March 1893.

SIR,

I HAVE the honor to submit the following report on the comparative observations taken at Madras, Kodaikanal, and Kotagiri during the past year with the view of determining the most suitable locality for the Solar Physics Observatory which it is proposed to establish.

A summary of the observations is given in an appendix to the report. They are also plotted out for ready examination in Plates I and II accompanying the report.

The following gives a verbal summary of the observations :—

(1) *Brief description of the hill stations.*—Kodaikanal is the hill station on the Palni hills, a nearly isolated group of mountains in the Madura district.

The Palnis are divided into two groups—an eastern and a western portion, of which the latter is considerably more elevated than the former, averaging about 7,000 feet. Kodaikanal is in the western portion at an elevation of about 7,200 feet. The ascent to it (from the south) is steep. The summit may almost be described as a rolling plateau. There is in the neighbourhood of Kodaikanal very little forest, and the hill country to the north, east, and west resembles the downs in the south of England. To the south lies the upper valley of the Vaigai, at present slightly cultivated, but which will, when the Periyar scheme has been accomplished, be speedily brought into a state of high cultivation by the system of irrigation which will then be opened.

Kotagiri is a small hill station in the Nilgiris. These hills form a mountain plateau which is united by a narrow and precipitous range of granitic peaks at the western extremity to the West Ghâts. Kotagiri is situated at the north-east end of the plateau, at an average height of about 6,500 feet above the sea. The plateau consists chiefly of grassy undulating hills, divided by narrow valleys. A large portion of the land near Kotagiri is taken up with tea and coffee plantations. The ground is much more broken up and uneven than at Kodaikanal.