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Variations in radiation, ozone and some meteorological and soil parameters during the eclipse on 23 November 1965 at Dum Dum

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ABSTRACT. On the solar eclipse day, 23 November 1965, the variations of radiation, total ozone content in the atmosphere and some other meteorological and soil parameters have been studied with the help of available instruments at Dum Dum observatory and discussed.

1. Introduction

It is well known that the amount of solar radiation intercepted and actually utilised by the earth-atmosphere system is of basic importance in diverse fields of meteorology. Radiation intensity during eclipses would rarely be homogeneous horizontally because of the phase difference in its occurrence. It is, therefore, proposed to study the variations of radiation, ozone amount, evaporation and surface temperature on 23 November 1965 solar eclipse.

2. Eclipse data for Dum Dum

The partial solar eclipse was visible between 0657 and 0941 IST. The maximum portion (89 per cent) of the sun's disc covered by the moon was at 0813 IST. The sunrise was at 0545 IST. These timings were provided by the Nautical Almanac Unit of Regional Meteorological Office, Calcutta.

3. Experimental set-up and data collection

The data collected in the present study consists of total radiation, diffuse radiation, net radiation, direct solar radiation, ozone amount, evaporation, surface temperature, dry and wet bulbs temperatures, visibility, tropopause height and temperatures.

A standard upward facing Moll-Gorczynski solarimeter was used to obtain direct plus diffuse solar radiation. Another upward facing Moll-Gorczynski solarimeter provided with a shading ring was used to obtain diffuse radiation. The difference between the two gives the vertical component of the direct solar radiation. By measuring the zenith distance of the sun with the aid of a pilot balloon theodolite, the direct radiation from the sun could be computed from the cosine relation. A non-ventilated, polythene shielded net radiometer designed by Funk (1959), CSIRO, Australia was used for obtaining net radiation. Ozone amounts were obtained with the help of Dobson's spectrograph. Evaporation and soil surface temperatures were obtained with Piche (exposed in Stevenson Screen) and ordinary mercury-in-glass thermometer with due precautions to its calibration and exposure respectively. Outputs of all radiometers were recorded on cambridge recorders. A dry and wet thermograph yielded dry and wet bulb temperatures and visibility was estimated with the aid of land marks. Temperature and height of the tropopause were obtained from radiosonde flights.

The observational programme was spread over five days centered on the eclipse day, 23 November 1965. Observations on the eclipse day were taken at intervals of 15 minutes from 0600 IST till 1030 IST. On the other days observations were taken only at intervals of 30 minutes from 0600 IST to 1000 IST. More or less the same meteorological conditions prevailed over the station during these five days.

4. Results and discussion

4.1. *Radiation patterns* — Table 1 shows variations of total, diffuse, direct and net radiations on the eclipse day from 0600 IST to 1030 IST. While all these radiations indicated minimum values at the time of maximum phase of the eclipse, there seems to be some lag in the decrement or increment at the times of starting and ending of the eclipse and this may be due to lagging after the first and last contacts in the field of the instruments of the intersection of the lunar penumbra with the optically important higher atmosphere. Conflicting reports are existing in literature about this phenomena (Miyake, Sekihara and Kawamura 1949; Ushiyama, Narita, Suzuki and Suzuki 1949; Abbot 1958; Pruitt and Crawford 1965).

Fig. 1 depicts the variation of total radiation, direct solar radiation, diffuse radiation and net radiation. For comparison, data for a few days just preceding and following the eclipse day are also plotted. The effect of the eclipse which has a maximum phase at 0813 IST at Calcutta, on the radiation intensities is clearly seen in the figure.

TABLE 1

Time	Total radiation	Diffuse radiation	Vertical component of solar radiation	Zenith distance in degrees	Solar radiation	Net radiation
0600	·01	·01	—			
0615	·04	·03	·01	86·6	·17	·00
0630	·10	·05	·05	84·2	·49	·00
0645	·51	·07	·08	80·9	·51	·02
0700	·21	·08	·13	78	·63	·05
0715	·25	·08	·17	75	·66	·08
0730	·24	·07	·17	71·9	·55	·07
0745	·19	·05	·14	69·2	·39	·03
0800	·11	·02	·09	66·5	·23	·02
0813	·06	·01	·05	64	·11	·03
0830	·17	·03	·14	61	·29	·06
0845	·34	·05	·29	58·5	·55	·18
0900	·53	·09	·44	56·3	·79	·30
0915	·69	·13	·56	54	·95	·41
0930	·83	·16	·67	52·1	1·09	·49
0945	·92	·17	·75	50·2	1·17	·51
1000	·92			48·5		·52
1015	·97	·17	·80	47	1·17	·56
1030	1·00	·17	·83	45·9	1·19	·58

NOTE — All radiation measurements are in gm cals/sq. cm/minute

TABLE 2

	Percentage reduction at	
	Maximum phase	Total period of eclipse
Total	90 %	34 %
Diffuse	93 %	42 %
Direct	89 %	34 %
Net	94 %	37 %

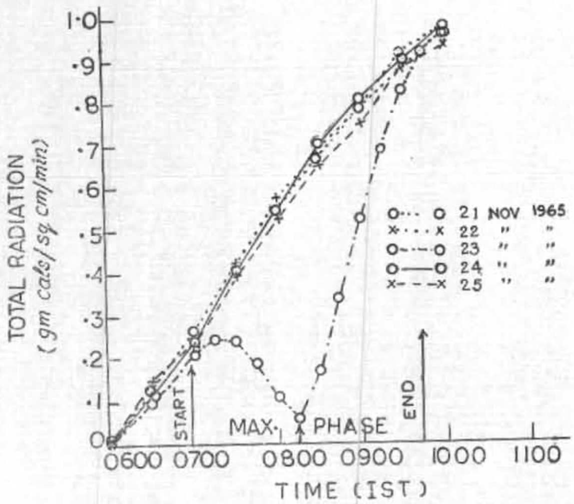

Fig. 1(a). Total radiation

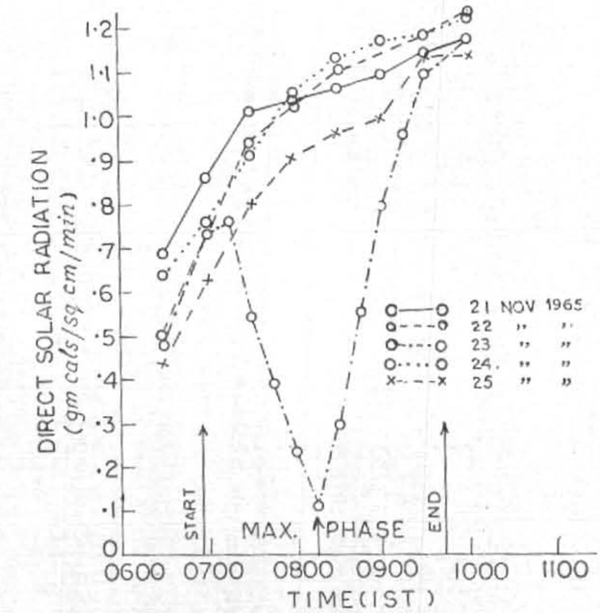

Fig. 1(b). Direct solar radiation

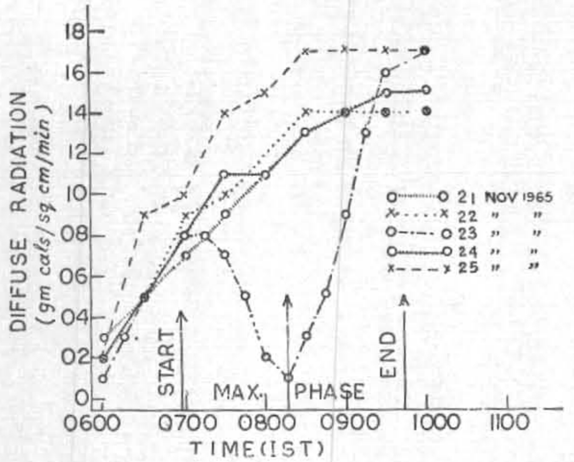

Fig. 1(c). Diffuse radiation

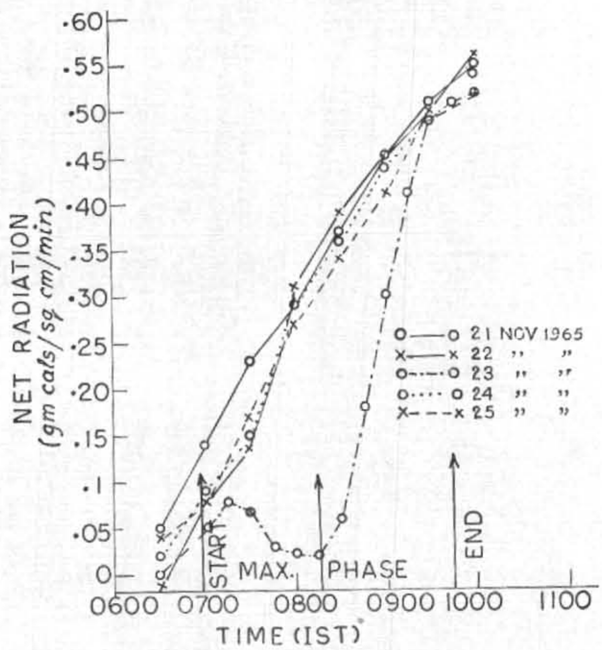

Fig. 1(d). Net radiation

In Table 2 are indicated the percentage reductions of total, diffuse, direct and net radiations at the time of maximum eclipse as well as for the whole eclipse period. As indicated earlier, the area of the sun affected by the eclipse at Calcutta at 0813 IST was 89 per cent. Table 2 indicates a reduction of 89 per cent for direct solar radiation with 89 per cent of obscurity unlike that reported by Jagannathan, Chacko and Venkiteshwaran (1957). The diffuse radiation is affected by 4 per cent more and hence the percentage reduction of total and net radiations were more than 89 per cent. In the right half of the Table 2 the percentage reductions of radiation values during the entire period of the eclipse have been summarised. Both direct and total radiations were reduced by 34 per cent. Maximum reduction was observed in the diffuse radiation.

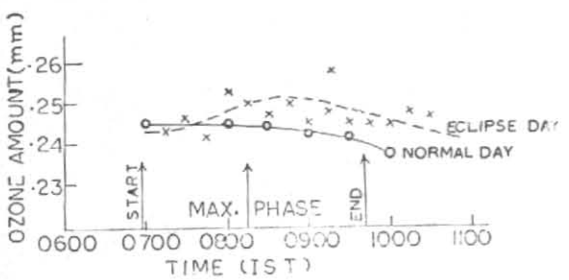

Fig. 2. Ozone variation

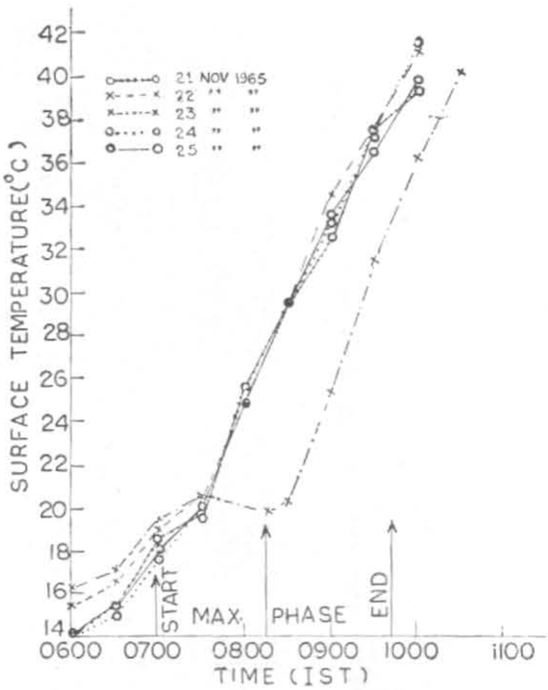

Fig. 3. Soil surface temperature

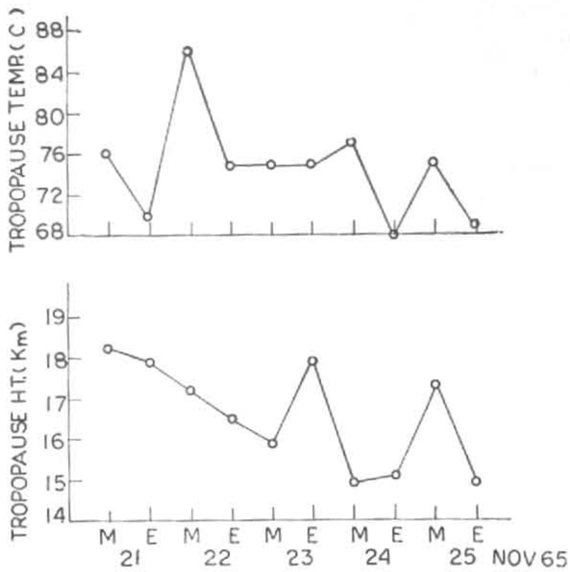

Fig. 4. Temperature (upper curve) and height (lower curve) of tropopause

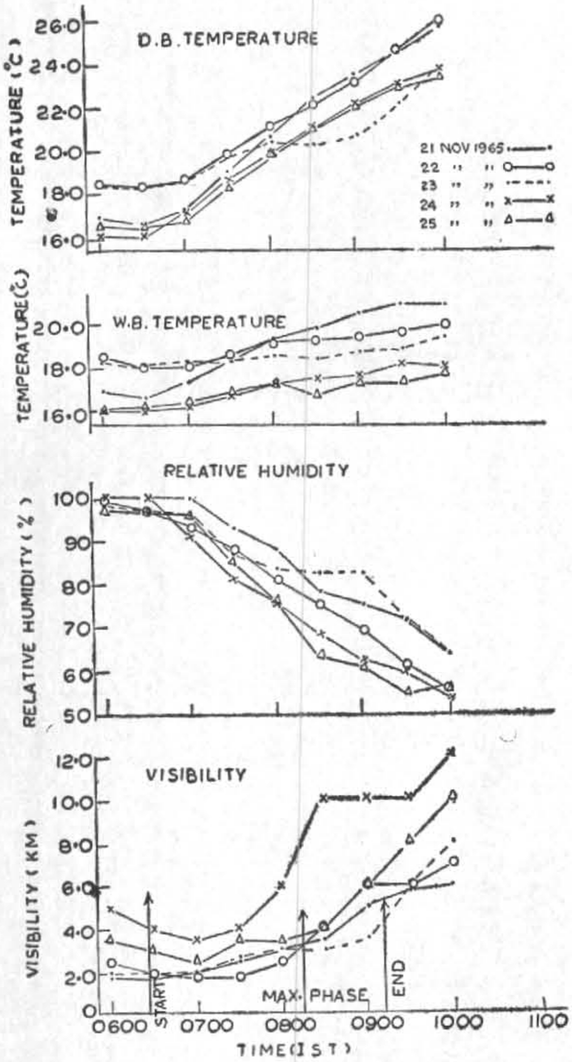

Fig. 5

4.2. *Ozone amount* — The ozone amount appears to have increased during the eclipse period by about 2·4 per cent at the time of maximum phase. On the eclipse day the quantity of ozone increased from the beginning, attained a peak value just after the time of maximum eclipse and then decreased. On a normal day (22 November 1965), the ozone content diminishes slightly towards noon and then rises again (Karandikar 1948); the same trend can be observed from the curve (normal day) presented in Fig. 2. The increase in the ozone content in the present case is probably due to increased formation of ozone than that of destruction for, the decrease or increase of ozone value with the inclination of the incident radiation depends upon the relative intensities of formation and destruction of ozone by the same solar radiation (Mitra 1952).

4.3. *Surface temperature* — The march of soil surface temperature as shown in Fig. 3 indicates that there is a lag of about 30 minutes for the temperature to decrease and recorded a minimum at about 0815 IST and again rose gradually. However, the temperature remained below that of other days for quite a long time.

4.4. *Temperature and height of tropopause* — An examination of Fig. 4 reveals that tropopause height generally decreases from morning to evening with consequent rise in its temperature. Conspicuously on 23 November 1965 the temperature at the tropopause did not change in the course of the day which eventually necessitated increase in the height of the tropopause in the evening as shown in the figure. An examination of the upper air soundings of both morning and evening of 23 November 1965 showed warming up of layers upto about 200-mb level only in contrast to other days which perhaps kept the tropopause temperature steady.

4.5. *Visibility* — Owing to the decrease of radiation during eclipse period the air temperature was lowered with consequent rise in relative humidity in the atmosphere. This caused the horizontal visibility to decrease during the eclipse period in contrast to other days which can be seen in Fig. 5. For comparison the dry bulb, wet bulb, relative humidity and horizontal visibility variations from 0600 to 1000 IST on the eclipse day as well as two days preceding and succeeding the eclipse day were presented in the same figure.

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