Meteorological Experiments During the Total Solar Eclipse of February 16, 1980

V.P. Verma, C.K. Chandrasekharan, K. Chatterjee S.M. Kulshreshtha and S.K. Das

India Meteorological Department, Lodi Road, New Delhi 110 003

(Received July 3, 1980, revised August 18, 1980)

Abstract

The India Meteorological Department (IMD) conducted special observations during the total solar eclipse on February 16, 1980. These observations were mainly desiged to study the effects of the total solar eclipse on the earth's immediate boundary layer and on the troposphere. Two special sites were chosen at Gadag and Raichur in Karnataka for extensive observations.

This paper deals with the preliminary results of the data collected at Gadag and from 21 observatories of IMD, in or near the path of totality, during February 14—18, 1980. Preliminary analysis indicates a very significant drop of about 20°C, in soil surface temperature and noticeable drop of about 2°C in the free air temperature in the earth's immediate boundary layer. Significant reversal of the radiation flow was also observed in the lower atmosphere during the eclipse.

INTRODUCTION

Indian subcontinent experienced a total solar eclipse on February 16, 1980. This provided an opportunity for the first time in India to obtain extensive meteorological observations during a total solar eclipse.

The following existing surface and upper air observatories, in or near the path of the totality, made more frequent observations for a period of 5 days between February 15-18, 1980.

Surface Observatories

(i) Bhubaneswar
(ii) Gopalpur
(iii) Puri
(iv) Paradip
(v) Sandheads
(vi) Chandbali
(vii) Koraput
(viii) Gadag
(ix) Raichur
(x) Hyderabad
(xi) Karwar
(xii) Mahboobnagar
(xiii) Kalingapatnam
(xiv) Kurnool
(xv) Bellary
(xvi) Dharwar

Upper Air Observatories

(i) Goa
(ii) Aurangabad
(iii) Hyderabad
(iv) Jagdalpur
(v) Bhubaneswar

Two special sites were chosen at Gadag and Raichur, in Karnataka, for extensive observations during the total solar eclipse. The sites at Gadag and Raichur were selected keeping in view the advantages due to high altitude of the Sun, duration of the totality, and their inland location, where the observations in the afternoon would not be vitiated by seabreeze. At these sites, the following special observations were made in addition to the conventional surface meteorological observations:

(a) Vertical temperature measurements, using balloon-borne radiosondes.

(b) Temperature variations in the boundary layer in the first 15 metres above ground surface.

(c) Incoming and outgoing radiations as measured on ground surface.

(d) Radiation measurements, in the vertical, using balloon-borne radiometer-sondes.

(e) Surface-based measurements of atmospheric electric potential gradient.

(f) Ozone measurements, both surface-based and balloon-borne ozone-sondes.

DATA

Soil Surface Temperature and Air Temperature

Surface meteorological observations (both with eye reading and recording instruments) for temperature, pressure, humidity, and wind were taken at Gadag on 15, 16, 17 and 18 February 1980. The soil surface temperature was also recorded at frequent intervals from 1400 to 1800 hours on the above four

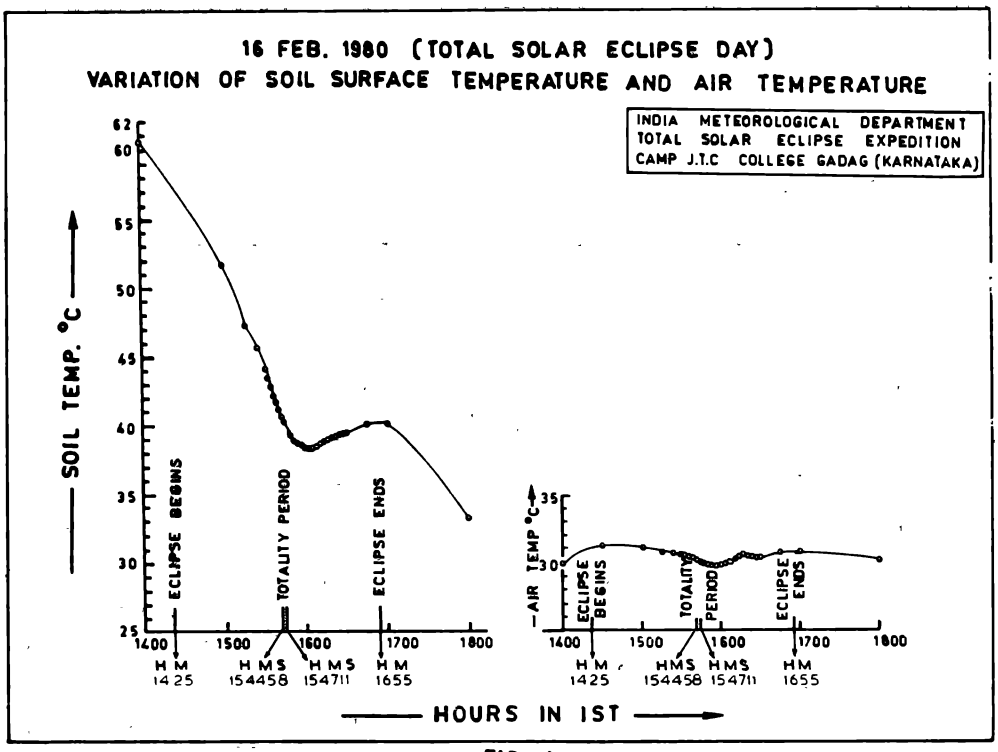

FIG - 1

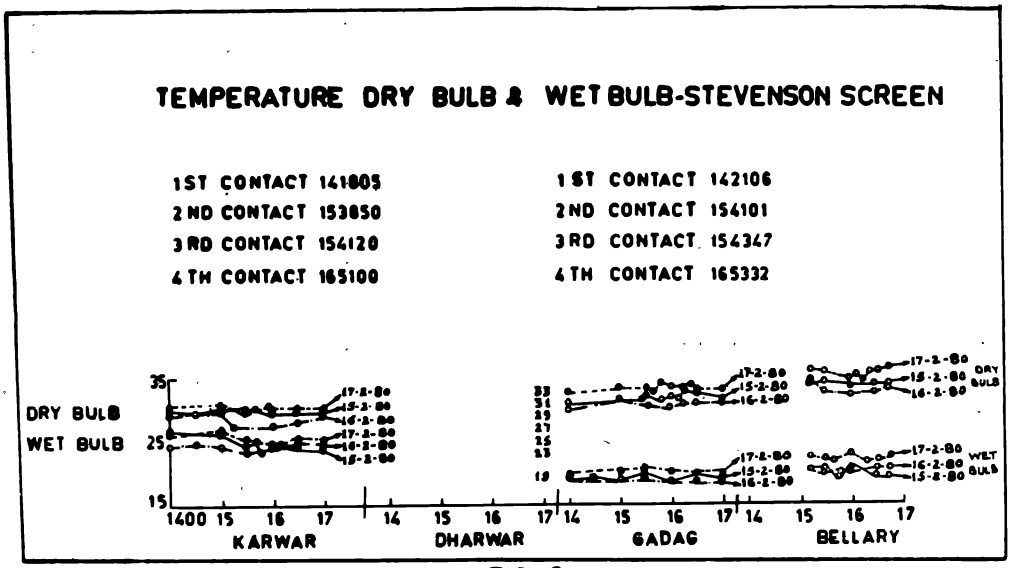

FIG. 2

TEMPERATURE DRY BULB & WET BULB STEVENSON SCREEN

WEATHER	DATE	WEATHER	DATE	WEATHER	DATE	WEATHER	DATE
CLOUDY Sc 4/8 CLOUDY Ci 1/8 CLOUDY Ci 1/8	17-2-80	CLOUDY Cu 1/8 CLOUDY Cu 1/8	17-2-80	CLOUDY Cu 3/8 CLOUDY Sc 1/8	17-2-80	CLOUDY Cu½Sc5/8 CLOUDY Sc 6/8	17-2-80
CLOUDY Ci 1/8 CLOUDY Ci 1/8 CLEAR SKY	16-2-80	CLOUDY Cu 1/8 CLOUDY Cu 1/8	16-2-80	CLOUDY Cu 3/8 CLOUDY Sc 3/8	16-2-80	CLOUDY Sc 5/8 CLOUDY Sc 6/8	16-2-80
CLOUDY Sc 4/8 CLOUDY Ac 5/8 CLOUDY Sc 5/8	15-2-80	CLOUDY Cu 1/8 CLOUDY Cu 1/8	15-2-80	Ci 1/8 Ci 1/8	15 2-80	CLOUDY Sc 5/8 CLOUDY Sc 5/8	15-2-80

1ST CONTACT	142300 IST	142700 IST	142742 IST	142800 IST
2ND CONTACT	154340 IST	154458 IST	154532 IST	–
3RD CONTACT	154522 IST	154711 IST	154627 IST	–
4RT CONTACT	163500 IST	165300 IST	165454 IST	165600 IST

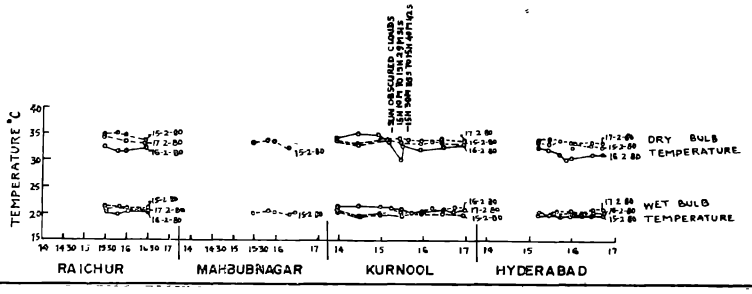

FIG. 3

TEMPERATURE DRY BULB & WET BULB - STEVENSON SCREEN

	WEATHER	WEATHER	WEATHER	DATE	WEATHER	WEATHER	DATE	WEATHER
TYPE OF CLOUD	CLOUDY $Sc_{3/8}\ Cu_{3/8}$	CLOUDY (THUNDER) $Sc\ Cu_{4/8}\ Cb_{1/8}$	CLOUDY (THUNDER) $Sc_{2/8}\ Cu\ Cb$	17·2·80	CLOUDY $Cu_{1/8}\ Cb_{1/8}$	CLOUDY $Cu_{1/8}\ Cb_{1/8}$		CLOUDY $Cu_{1/8}$
	CLOUDY $Sc_{3/8}\ Cu_{2/8}$	CLOUDY $Sc_{2/8}\ Cu_{2/8}$	CLOUDY $Cu_{2/8}\ Cb_{2/8}$	16·2·80	CLOUDY $Sc_{2/8}\ Cb_{1/8}$	CLOUDY $Cu_{1/8}\ Cb_{1/8}$		CLOUDY $Cu_{1/8}$
	CLOUDY $Sc_{4/8}\ Ac_{3/8}$	CLOUDY $Cb_{3/8}\ Ac_{2/8}$	CLOUDY (THUNDER) $Sc_{4/8}\ Cb_{4/8}$	15·2·80	CLOUDY $Cu_{2/8}\ Ac_{6/8}$	CLOUDY $Cu_{3/8}\ Cb_{1/8}$	15 2·80	

1st CONTACT	144216	1st CONTACT	144600
2nd. CONTACT	155446	2nd CONTACT	155609
3rd. CONTACT	155535	3rd CONTACT	155810
4th CONTACT	165935	4th CONTACT	170000

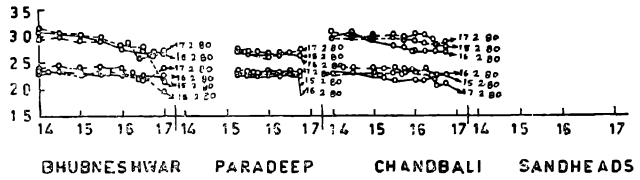

FIG - 4

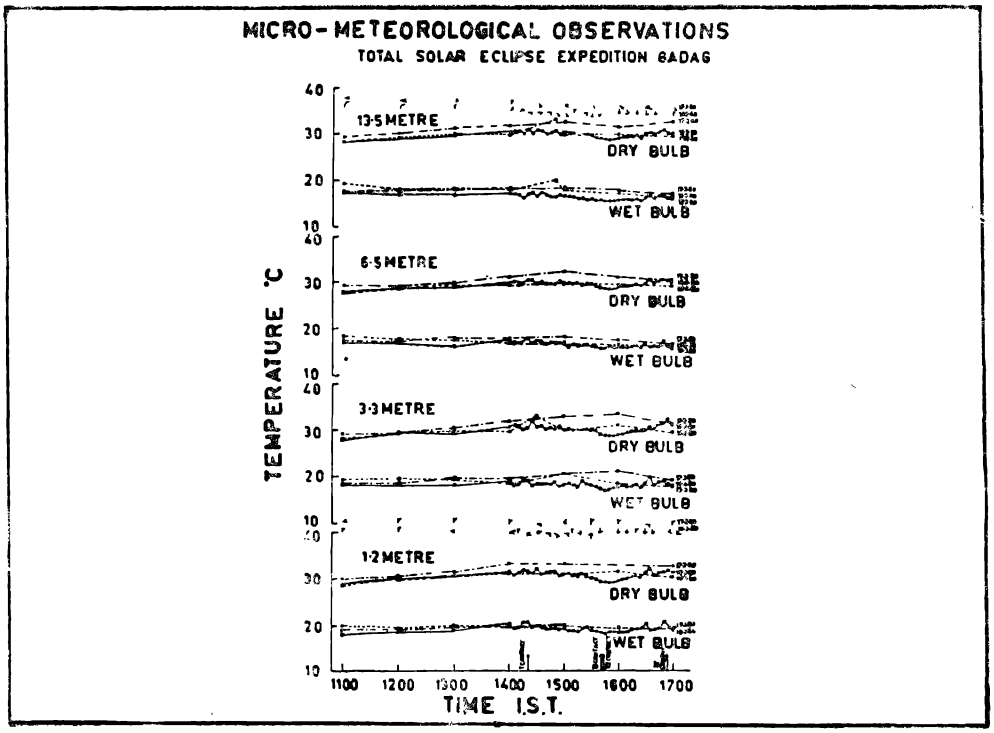

FIG. 5

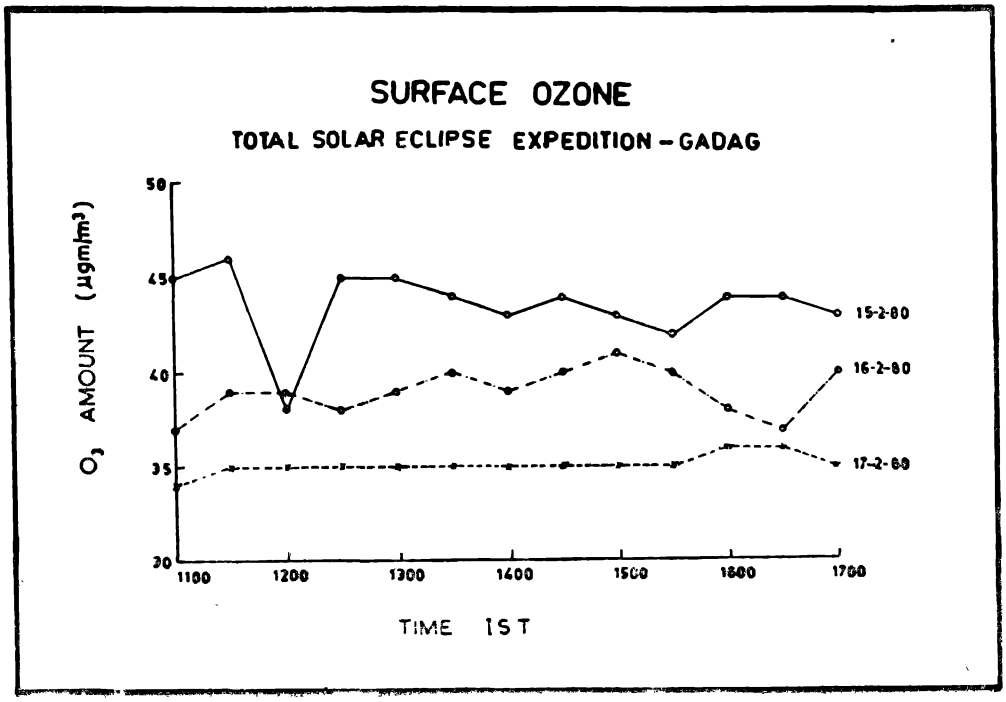

FIG. 6

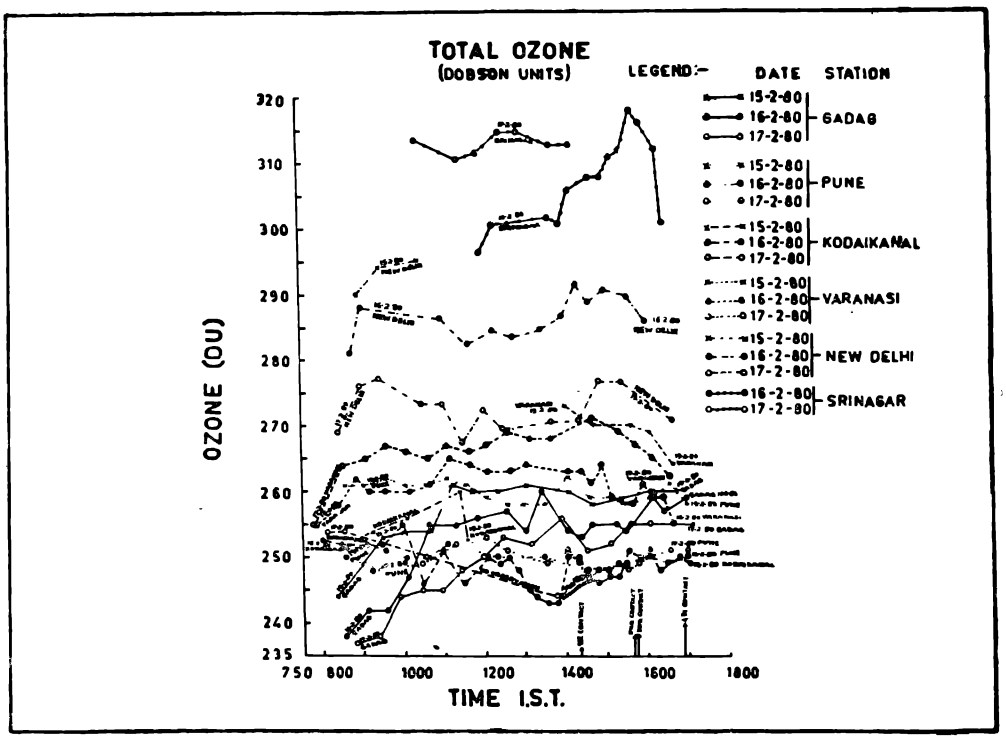

FIG. 7

days. Observations on soil surface temperature and air temperature have been plotted (Figures 1 to 4) and analysed.

MICROMETEOROLOGICAL DATA FROM 13.5 m TOWER

Variation of wind at 1.2 and 13.5 m and the dry bulb and wet bulb temperatures at 1.2, 3.3, 6.5 and 13.5 m, above the ground level, were continuously recorded and monitored at Gadag between February 15-17, 1980. These observations of wind speed and air temperature, at the various levels, have been plotted in Figure 5.

Surface Ozone

Surface ozone recorder, with electromechemical sensor, both indigenously developed, was used to measure the ozone concentrations near the earth's surface. The Ozone concentration of the atmosphere, near the surface, was obtained and recorded by the Ozone sensor, and has been plotted in Figure 6.

Total Ozone

Dobson Ozone Spectrophotometer was installed at Gadag to study any possible effect of solar eclipse on atmospheric ozone. Continuous measurements of total ozone amount were made on the 15th, 16th and 17th February 1980 from Gadag and other four stations in India. The values of the total ozone have been plotted in Figure 7.

DISCUSSION AND ANALYSIS OF THE VARIOUS SURFACE OBSERVATIONS

Soil Surface Temperature

From a preliminary analysis as revealed in Figures 1 to 4, the following salient features are noticed:

On the 15th and 17th February 1980, the temperature variation pattern at all these stations practically follow the normal expected trends, modified at times, by local weather conditions like passing clouds, rain etc.

The most striking feature of the variations of the soil surface temperature at Gadag during the period of eclipse is the sharp fall of the soil surface temperature from 60.5°C at 1421 IST to 38.4°C at 1600 IST° This occurred about 16 minutes after the end of the totality at Gadag. The rate of fall of temperature was 1 °C/6 min (i.e. 0.16 °C/min) for the first 40 min; it increased to 1°C/4 min (0.25° /min) for the next 40 min. and further increased to 1°C/min at the time of totality. The rate of rise of temperature after the 3rd contact was rather slow. It was observed to be 1°C/35 min (0.03°/min). On the 15th and 17th, the soil surface temperature followed the diurnal trend.

Air Temperature

Figures 1 to 4 also indicate that the maximum fall in free air temperature (as recorded in Stevenson Screen) occurred at about 15 minutes after the totality at all the stations except at Bhubaneswar and Chandbali and the temperature drop was of the order of 1.5 to 3.0°C Later, most of the stations showed the normal tendency of increase in temperature but Bhubaneswar and Chandbali showed a tendency of gradual decrease even after the eclipse was over. This is probably due to the cloudiness over these two places.

Micromet Tower Observations

One striking feature, which is revealed from the preliminary analysis of micromet observations (Figure 5), is that the wind from surface to 13.5 m was practically calm during the entire duration of the eclipse over Gadag.

The air temperature (dry bulb) showed a much higher rate of fall at the lower level than at the higher levels and the minimum wet bulb and dry bulb temperatures were recorded a few minutes earlier to the time of the occurrence of the minimum soil surface temperature on the 16th at Gadag. At all the levels, the dry bulb temperature after 1200 hours IST was higher on the 17th than on the 15th at the corresponding hour.

Surface Ozone

In Figure 6, note that there was a gradual fall in ozone concentration from the 15th to the 17th. The other striking feature, which may have some bearing with the totality of the solar eclipse, is revealed in the general variation of surface ozone on the 16th; it showed a dip in the ozone concentration at the surface after the totality at about 1630 hours IST. This tendency was absent on the other two days. In fact, on the 15th and 17th, the ozone concentration started rising and the maximum occurred at 1630 hours, whereas on the 16th the concentration was minimum at 1630 hours. On a scrutiny of the synpotic situation, it is seen that just before and during the totality of the solar eclipse over Gadag, the surface wind was calm from surface to 13.5 m above ground and considerable cooling of the air occurred near the ground surface. This feature is quite significant and needs further examination with similar data at other observation centres on these days. Further study may reveal information on the formation and transportation of ozone in the atmosphere.

Total Ozone

An analysis of the total ozone variation plotted in Figure 7 shows that the total ozone remained practically unaffected during the total solar eclipse on February 16, 1980 over the entire country.

ACKNOWLEDGEMENT

The authors wish to express their grateful thanks to the Director General of Meteorology for kind permission to communicate this paper and for providing all facilities for the study. The authors also express their sincere appreciation to all the scientists of the Department associated with this extensive observational programme.