SOME ATMOSPHERIC RESPONSES DURING THE 11 AUGUST 1999 TOTAL SOLAR ECLIPSE NEAR BUCHAREST

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Abstract. Radiation and thermal responses were measured during the 11 August 1999 total solar eclipse at Afumaţi atmospheric laboratory near Bucharest and at Căldăruşani experimental hydrological station in Romania. It was found that the surface temperature at the first station dropped by 16.6°C to 29.9°C. Temperatures at 10 m, 7 m, 3 m and –5 cm also dropped to nearly this temperature. Although the temperature at Căldăruşani was 34.1°C at the start of eclipse, the minimum temperature reached was 29°C. An independent observer at Călăraşi also found the minimum temperature to be about 30°C. In other words, the minimum temperature reached following the totality was 29 ± 0.5°C irrespective of location and height (from –5 cm to 10 m). This may be explained if the temperature of the shadow is about 29.5°C. The response time of the minimum temperature at the surface was about 18 minutes, which is comparable to the time when net radiation was negative. Net radiation dropped between 468 W/m^2 to –39 W/m^2 at Căldăruşani. Cooling of air in response to cutting off the solar radiation must have caused changes in wind patterns.

Key words: solar eclipse – atmospheric responses – temperature – UVB – global radiation – net radiation.

1. INTRODUCTION

Solar eclipses provide a unique opportunity to investigate the solar radiation transfer and the thermal response of the Earth's atmosphere. In 1969, a NATO

Advanced Study Institute devoted to solar eclipses and ionosphere was held in Greece. The National Geophysical Data Center NGDC has recently (1999) displayed electron temperature and electron density plots for the 10 May 1994 annular eclipse and found that the eclipse affected the upper atmosphere above Haystack. Mueller-Wodarg et al. (1998) performed a modelling study of the effects of mid-latitude solar eclipse on the thermosphere and ionosphere. In 1999 Mueller-Wodarg displayed a sample animation showing changes of temperature at the altitude of 240 km caused by the Moon's shadow at the 11 August 1999 solar eclipse. Temperature drops, amounted to 50°, generated waves which propagated globally.

2. EXPERIMENT AND DATA

Digital automatic recordings have been carried out at two automatic weather stations: Afumaţi atmospheric physics laboratory (Lat. 44° 30', Lon. 26° 13') and Căldăruşani experimental hydrological station (Lat. 44° 40', Lon 26° 17'). Thies Clima German company produced the sensors used at the first station. The temperature has been measured at heights of 10 m, 7 m, 3 m, 0 m and –3 cm. Global, net radiation and UVB radiation have been measured at 2 m by two sensors produced by Kipp & Zonen Dutch company.

During the eclipse, data have been recorded every 10 seconds. For comparison, data have been collected one day before the eclipse at one minute interval and one day after the eclipse at 10 min interval at Afumaţi and all the time at 30 sec at Căldăruşani.

3. SOLAR RADIATION TRANSFER

Although the sky was clear during totality at both stations, the measurements were disturbed by altocumulus clouds before and after totality. Fig. 1 shows the drop of the global radiation at 0.3 μ - 3.0 μ as well as UVB at 0.290 μ - 0.315 μ in response to cutting off the solar radiation during the eclipse. The UVB minimum dropped to a flat minimum for a long period, while the global radiation showed a sharp minimum at totality. Attenuation of radiation by clouds caused by absorption and diffusion can be corrected to give clear sky decrease of radiation only due to the portion of the uneclipsed Sun. The following mathematical model gives a value for the flux of global radiation for every moment during the eclipse.

The asymmetry of global and UVB curves is due to the variation of the altitude of the Sun following totality.

The net radiation is defined by the difference between the downward and the upward flux at 0.3 μ - 50.0 μ. Fig. 2 indicates the symmetry of the net radiation around totality . Net radiation is not disturbed by clouds as in the case of global radiation because the effect of clouds cancels out from both terms by subtraction. The symmetry of net radiation within the experimental error can be attributed to the previous comment. Irregularities in net radiation curve may be attributed to irregularities of the Moon's surface and can be used to give information about the extensions of valleys and mountains of the Moon. The minimum time of the net radiation is 14 h 06 m 05 s at Căldăruşani. Radiation balance occurs at about 13 h 58 m 05 s and 14 h 15 m 05 s, i.e. net radiation was negative for a period less than 17 minutes . The recordings of the net radiation are averaged every 30 seconds. Radiation balance at the eclipse decreased between 468 W/m^2 to -39 W/m^2 at Căldăruşani. Net radiation was 507 W/m^2 in the previous day at 13 h 58 m 05 s, and at 14 h 15 m 05 s this value was 494 W/m^2. The day after the eclipse, net radiation was 492 W/m^2 at 13 h 58 m 05 s and 380 W/m^2 at 14 h 15 m 05 s.

To draw a conclusion, net radiation dropped during the eclipse by more than 500 W/m^2. Global radiation was minimum between 14 h 05 m and 14 h 09 m.

4. THERMAL RESPONSES DURING THE ECLIPSE

Such responses at Afumaţi are presented in Fig. 3 for the following heights: 10 m, 7 m, 3 m, surface, and 5cm below surface.

The minimum temperature at –5 cm was 29.7°C at 14 h 26 m and was kept constant for few minutes. The time response of the minimum at the surface temperature was about 18 mim after totality. This time is about the time when the net radiation was negative.

The comparison between the cooling and heating rates of the soil at both surface and subsurface can be used to study the radiation and conduction properties of the soil at such a location. There is slight difference between air temperatures at the three heights 10 m, 7 m, and 3 m during the partial phases of the eclipse, with the 3 m temperature systematically higher than the 7 m one, which is in turn higher than the 10 m one, but the situation reversed following totality. However, one can say that both the air and ground temperatures dropped to a value around 30°C.

In the case of Căldăruşani, the air temperature dropped from a maximum of 34.1°C at 12 h 24 m 35 s to a minimum of 29°C at 14 h 19 m 05 s.

Şt. Berinde measured temperature variations at Călăraşi, east of Bucharest, and found that the temperature dropped from about 34.5° C to 30°C.

5. CONCLUSIONS

A study of atmospheric responses due to the 11 August total solar eclipse indicates that both of the global and UVB radiation dropped dramatically to a minimum around totality. There is a chance to study attenuation of such a radiation due to clouds. The net radiation became negative for about 17 minutes at Căldăruşani.

The temperature dropped to about 30°C following totality at both Afumaţi and Călăraşi, although at the beginning of eclipse it was about 46.5°C at Afumaţi and 34°C at Călăraşi. At Căldăruşani, the surface temperature dropped from 34.1°C to 29°C. It seems likely that the air temperature inside the umbra is between 29-30°C.

The response time of minimum surface temperatures was about 18 minutes, which is comparable to the duration of the negative part of the net radiation when the backward radiation became higher than the incident radiation.

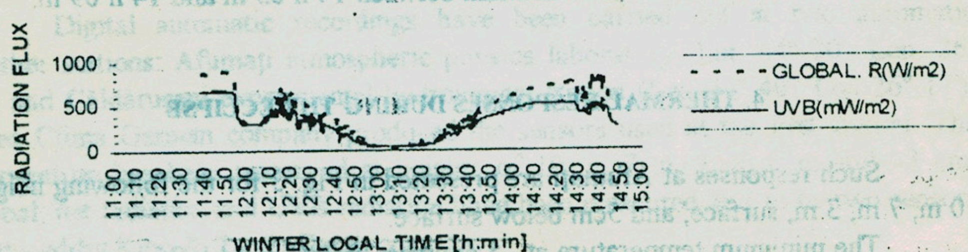

Fig. 1 - Radiation response of the atmosphere at the Atmospheric Physics Observatory during the eclipse.

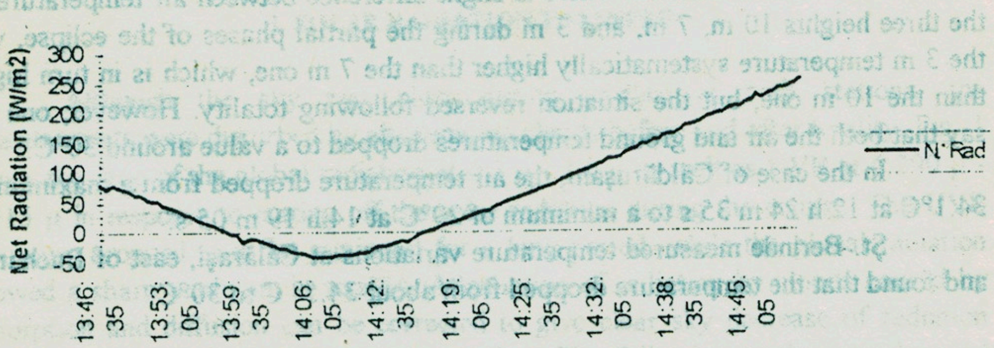

Fig. 2 - Time series of net radiation.

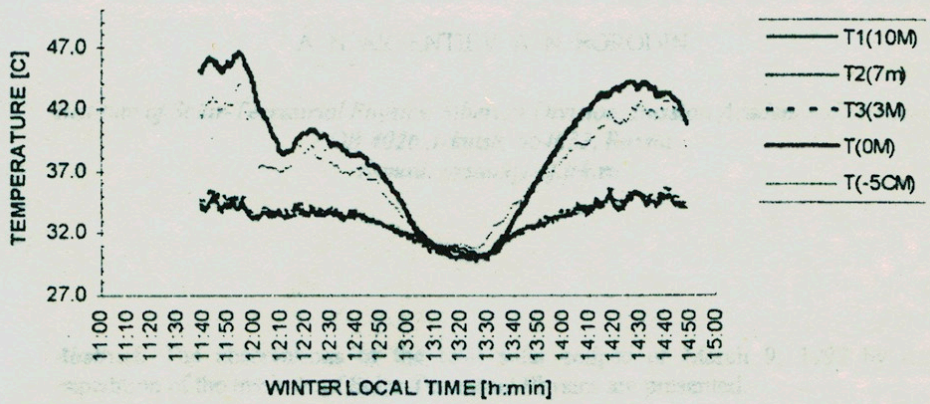

Fig. 3 - Thermal response during the eclipse at the Atmospheric Physics Observatory.

Such air cooling during the eclipse must have produced contraction in the air, which must have made changes in wind patterns. Further studies should include wind speed and direction. The shadow of the Moon races through the atmosphere at supersonic speeds, causing waves to spread through the atmosphere from the eclipse region(Mueller-Wodarg, 1999)

REFERENCES

Anastassiades, M. (ed.): 1970, *Solar Eclipses and the Ionosphere*. A NATO Advanced Studies Institute held in Lagonissi, Greece, May 26 - June 4, 1969, Plenum Press, New York, London, 1970.

Mueller-Wodarg, I. C. F.: 1999,: http://wdc.rl.ac.uk/ionosondes/eclipse/temperatures.html.

Mueller-Wodarg, I. C. F., Daylward. A., Lockwood, M.: 1998, *Geophys. Res. Lett.*, **25**. 3787.