Kodaikanal Obs. Bull. (1997) 13, 167-173

Infrared Solar Radiation Measurement during Total Solar Eclipse

S.L. Jain, B.C. Arya, S.K. Singh, O.P. Tripathi and A. Hamid
Radio Science Division, National Physical Laboratory, Dr. K.S. Krishnan Road,
New Delhi 110 012

Abstract

The occurrence of Total Solar Eclipse on October 24, 1995 provided an unique opportunity to conduct some experiments using IR sun photometers in the spectral range 0.75 μm to 1.6 μm and 2.5 to 14.5 μm during eclipse at Nim Ka Thana (27° 47'N, 75° 47'E) and New Delhi (28° 39'N, 77° 13'E) respectively. The measurements have been used to estimate the amount of water vapour, ozone etc. A significant variation in IR solar irradiance at various window wavelengths during the solar eclipse was observed. Also measurements of temperature and humidity were made on regular interval from 22nd to 26th October 1995. In the present paper the experimental set up and results obtained are discussed.

Key Words : Solar Eclipse, Water Vapour, Ozone, IR radiation

Introduction

The total solar eclipse is one of the many grand spectacles offered by nature. The atmospheric conditions change during the solar eclipse due to transitory blockage of solar radiation reaching the earth's surface. The measurement of solar radiation in IR spectral region is of great significance to understand the physics, chemistry and radiation budget of the atmosphere. A large number of experiments were conducted during the last total solar eclipse on Feb. 16, 1980 in India (Bhattacharryya 1990). The occurrence of Total Solar Eclipse on October 24, 1995 again over India provided an unique opportunity to take some special solar radiation measurements in the infrared spectral region. The experiments were conducted during, after and before the total eclipse at Nim Ka Thana (27° 47'N, 75° 47'E) and the New Delhi (28° 39'N, 77° 13'E) in the spectral range 0.75 µm to 1.6 µm and 2.5 to 14.5 µm respectively using IR sun photometers. The data are being used to estimate the water vapour (.94 µm & 1.14 µm), ozone (9.6 µm) and turbidity (1.01, 1.2, and 1.58 µm etc.). The experiments were conducted in the premises of S.N.K.P. Govt. College at Nim Ka Thana which was in the totality path and NPL, New Delhi having partial eclipse of maximum obstruction of 95.75%. In the present communication the experimental set up and results obtained will be

discussed in detail. The details of circumstances of solar eclipse at these two places are given below.

Place	Long	Lat.	Eclipse begins IST h m s	Totality begins IST h m s	Totality ends IST h m s	Eclipse ends IST h m s	Duration in sec. of totality
Nim Ka Thana	75° 47'E	27° 47'N	07 24 10	08 32 20	08 33 10	09 50 30	50
Delhi	77° 13'E	28° 39'N	07 24 58	Greatest phase 08 34 08	obstruction 95.754%	09 52 25	——

Experimental set up

The solar spectrum observations in the 0.8 μm – 1.6 μm spectral range were made on clear days with a high resolution grating monochromator of focal length 240 mm (spectral resolution better than 0.1 nm). A heliostat was used to get solar radiation reflected in a fixed direction in the laboratory. The solar radiation is chopped and focused by ZnSe lens on the entrance slit of monochromator. The signal is detected with the help of pyro-electric detector. A signal output from the detector and the chopper reference frequency are fed to the signal channel and the reference channel of the lock-in amplifier respectively. The synchronous detection takes place in the lock-in amplifier. The signal output from the lock-in amplifier is directly recorded on the strip chart recorder. The systems used to monitor IR solar spectra during the solar eclipse at NPL and Nim Ka Thana were slightly different.

Results and Discussions

The IR solar spectra obtained from October 22 to October 26, 1995 were used to get various atmospheric parameters.

Temperature and Humidity

The ambient atmospheric air temperature and relative humidity were measured during, before and after the solar eclipse day from 23rd to 26th October 1995 at Nim Ka Thana. The variation of temperature and humidity is shown in Fig.1 for different days. It is found that the relative humidity increased while the temperature decreased during eclipse as expected. The measurements were made using a digital temperature and humidity sensor at 1 meter above the second floor of SNKP college building. The actual temperature drop from start of eclipse to maximum phase was only 1.5°C. However the temperature difference around 08.30 hrs (totality) on 24.10.95 and other control days was 6-8°C. The relative humidity increased by

4% only during the eclipse period. However, the relative humidity difference on control day and eclipse day around 08.30 hrs (totality) was found to be 8-10%. The increase in relative humidity is due to decrease in temperature which is due to solar eclipse as they are reciprocally related.

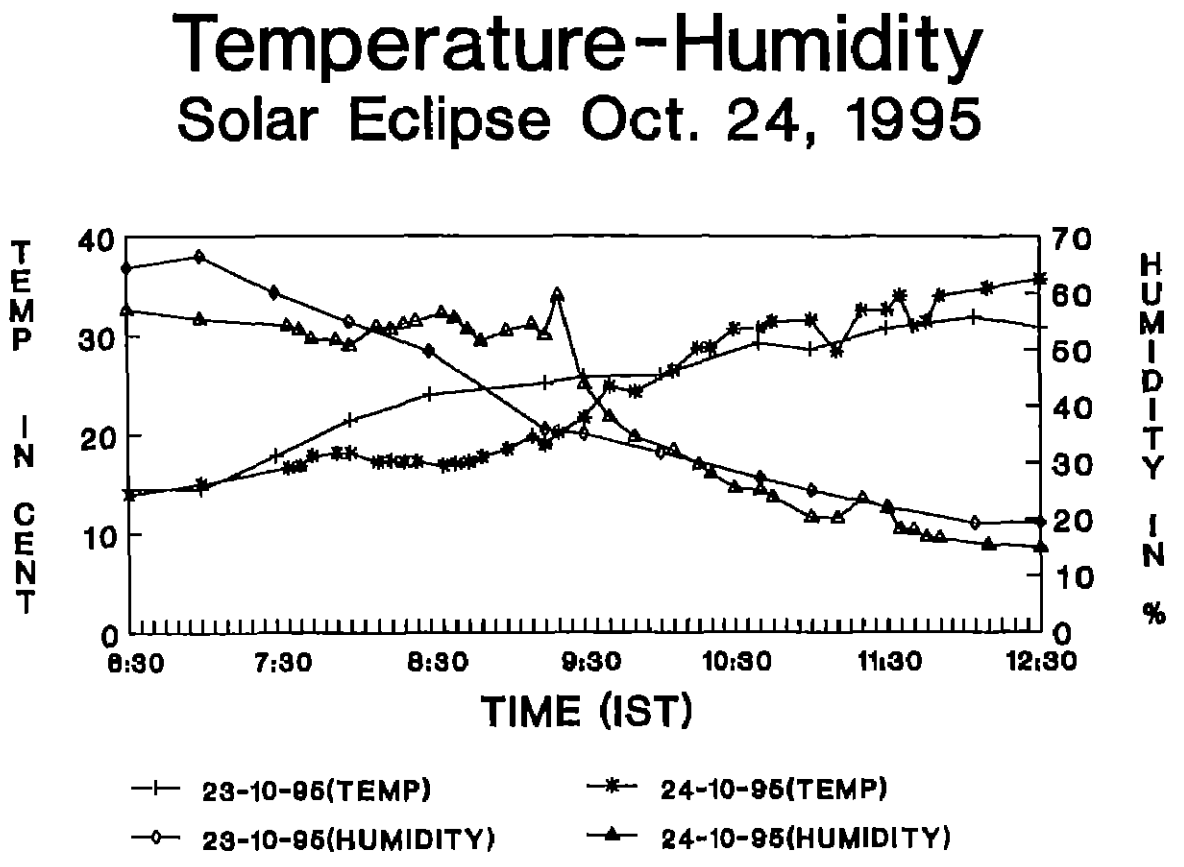

Figure 1 : Variation of ambient atmospheric air temperature and humidity at Nim Ka Thana (Raj), India, during total solar eclipse.

Water Vapour

The measurements of atmospheric water vapour play an important role in the study of climate and radiation budget etc. The infra-red solar radiation absorption spectrum in the spectral range 0.8 to 1.6 μm shows well documented absorption band of water vapour at 0.935 μm, 1.14 μm and 1.38 μm. The attenuation of the IR radiation at 1.14 μm band has been used for estimation of water vapour during, before and after the solar eclipse at Nim Ka Thana. The variation of water vapour estimated during control day and solar eclipse day is depicted in Fig.2. The water vapour is although a highly variable constituent in the atmosphere yet a clear indication of decrease in water vapour is seen during the solar eclipse and was minimum at the time of totality.

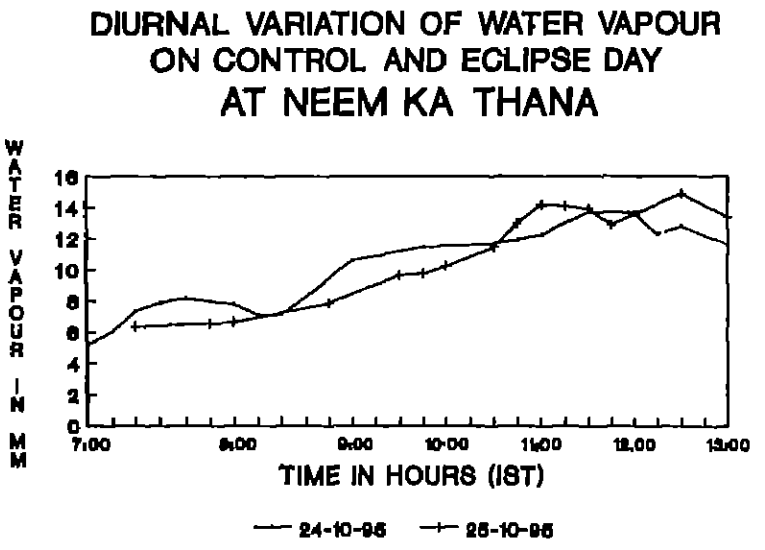

Figure 2 : Diurnal variation of water vapour during total solar eclipse (24.10.95) and control day (25.10.95) observed at Nim Ka Thana (Raj), India.

Ozone

The ozone is a very important minor constituent in the atmosphere. One cannot think of any kind of life on this planet in the absence of ozone layer in the atmosphere because it acts as an umbrella and shields our planet from the harmful ultra violet-B radiations coming from the Sun. Ozone has a very strong absorption band at 9.6 μm and the observations during the partial Solar Eclipse and control days in 2.5 μm to 14.5 μm spectral range using the IR sun photometer were used to estimate total column ozone at NPL, New Delhi as depicted in Fig. 3. No appreciable variation of ozone was observed during the total solar eclipse day as expected. However it is seen that the total ozone on eclipse day was slightly less than that on control days.

IR Solar Radiation

Nim Ka Thana

The IR solar radiation was measured in the spectral range 0.7 to 1.6 μm from October 23 to October 26, 1995. The variation of IR solar radiation at 1.2 μm and 1.01 μm on October 24, 1995 and October 25, 1995 is depicted in Fig. 4. It is found that IR solar radiation started to decrease as soon as solar eclipse started and was minimum during the totality and became normal after the end of eclipse.

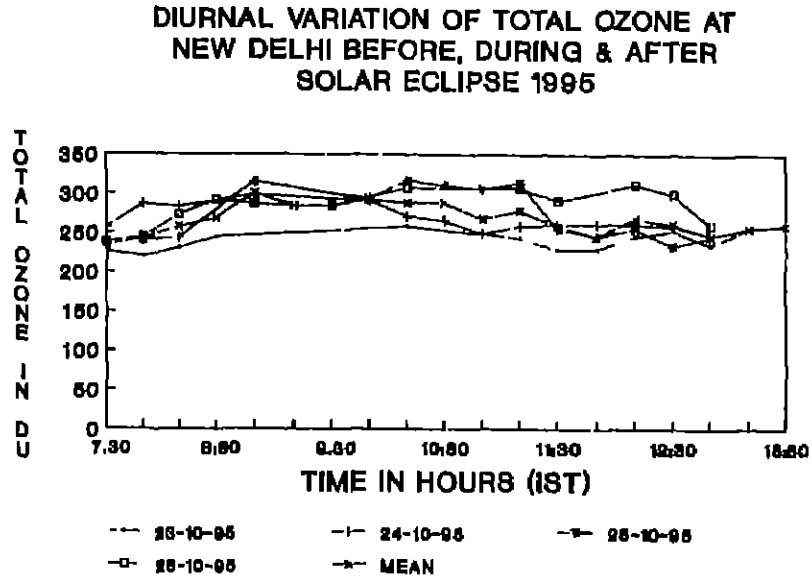

Figure 3 : Diurnal variation of Total Ozone at New Delhi during solar eclipse (24.10.95) and control days (23.10.95, 25.10.95 & 26.10.95).

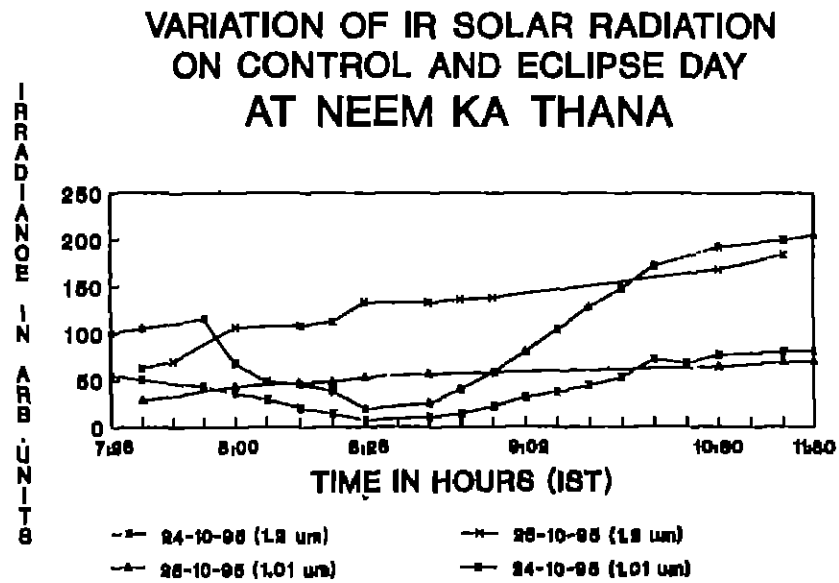

Figure 4 : Variation of IR Solar radiation at 1.2 μm and 1.01 μm on total solar eclipse (24.10.95) and control days 25.10.95 measured at Nim Ka Thana (Raj), India.

NPL, New Delhi

The variation of IR solar radiation measured at NPL, New Delhi on October 23 and 24, 1995 at 9.72 μm and 9.48 μm is shown in Fig. 5. It is found that IR radiation drastically

decreased during the solar eclipse and was minimum during the maximum obstruction around 8.30 hours. The IR solar radiation reached its normal value at the end of the eclipse.

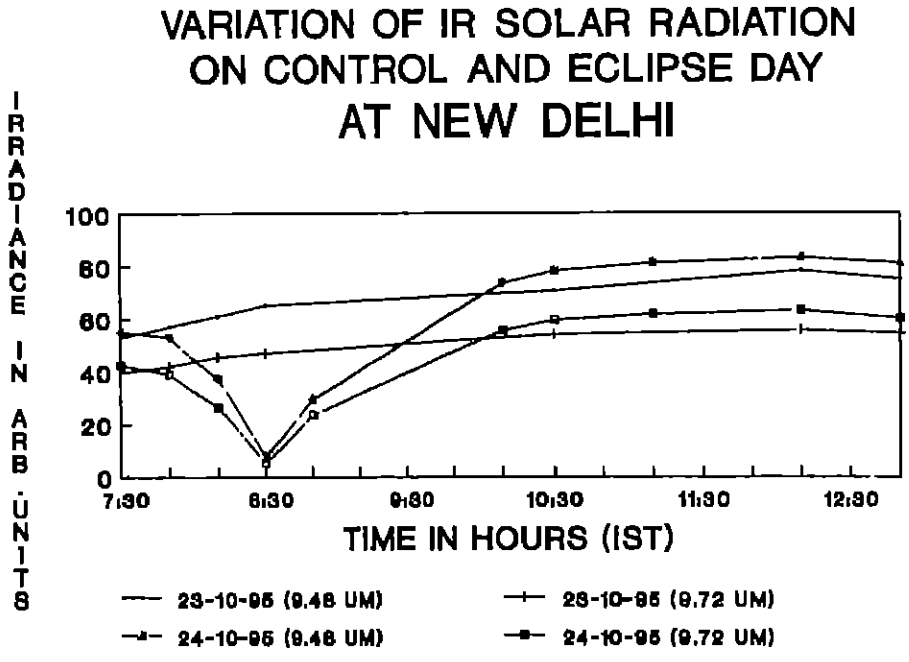

Figure 5 : Variation of IR Solar radiations at 9.48 μm and 9.72 μm during solar eclipse (24.10.95) and control day (23.10.95) measured at New Delhi.

Shadow bands

We tried to see the shadow bands by spreading 3 meter by 3 meter white sheet on the roof of the SNKP college but we could not see any sign of shadow bands.

Solar Dust Ring

The existence of a dust ring around sun has been shown by theoretical (Peterson, 1963, 1967 & 1969) and experimental work (Debi Prasad, 1995, Rao *et al.*, 1981, MacQueen *et al.*, 1968 and Over, 1958). It has been suggested that enhanced infrared radiation observed during solar eclipse at a distance of $4R_O$ from the centre of the Sun is due to the sublimation of dust grains as they spiral into Sun because of the Poynting - Robertson effect. However this enhanced radiation was not observed always, in some cases it was present while it was not observed at other times (Russell, 1929). The observations were carried out to see the existence of dust ring during total solar eclipse at Nim Ka Thana monitoring IR radiation at 2.2 μm using IR Sun photometer. The observation shows some radiation on both sides away from the Sun, but the signal level was very low and very difficult to draw any conclusion from our observation regarding the existence of the dust ring around the Sun. Also as the scanning

across the solar disk was done manually, there may be an error in the estimation of distance from the sun's center.

Acknowledgements

We express our sincere gratitude to Prof. E.S. Rajagopal, Director, NPL and Dr. K.K. Mahajan, Head, RASD, for their encouragement during the progress of the work. Thanks are also due to Principal and Vice Principal S.N.K.P. Government College, Nim Ka Thana for providing all logistic support to conduct experiments during solar eclipse in the college premises.

References

Bhattacharya J.C. Indian J. Radio and Space Phys. 1990, 19, 525.

Debi Prasad C., Solar Phys. 1995, 159; 181.

MacQueen R.M. Astrophys. J. 1968, **154**, 1059.

Over J. Proc. Kon. Neder. Akad. Wetensch 1958, B **51**, 74.

Peterson A.W. Astrophys. J. 1963, **138**, 1218.

Peterson A.W. Astrophys. J. 1967, **148**, L 37.

Peterson A.W. Astrophys. J. 1969, **155**, 1009.

Rao U.R., Alex R.K., Iyenger V.S., Kasturirangan K., Marar T.M.K., Mathur R.S. and Sharma D.P. : 1981, Nature 289, 779.

Russell H.N. Astrophysics J. 1929, **61**, 49.