Aerosol measurements at Roorkee relating to the total solar eclipse of 24 Oct. 1995

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The effect of total solar eclipse on aerosol size and concentration has been studied. Results of the measurements reveal an increase in the aerosol number concentration in the sub-micron and micron size ranges. The increase occurred after a time lag of about 70 min from the beginning of the eclipse. This may be explained in terms of the effect of condensational growth due to increased relative humidity.

1 Introduction

A total solar eclipse occurred on 24 Oct. 1995. Measurements were made to examine its effect on the atmospheric aerosols. The eclipse was total in most parts of Rajasthan, Uttar Pradesh and West Bengal, lasting from 0725 hrs IST to 0945 hrs IST. In Roorkee the totality was 90% with the centre at 0831 hrs IST. A total solar eclipse was last seen in India across the southern Indian peninsula on 16 Feb. 1980. There exist voluminous reports which investigate the atmospheric effects of the eclipse such as the solar radiation and surface temperature measurements[1], atmospheric conductivities[2], surface atmospheric electricity[3], measurements of field intensity of radio signals[4], ionospheric effects[5], etc. However, reports of measurements on the eclipse-related behaviour of atmospheric particles are rare. These types of measurements play a significant role in interpreting the changes in radiation budget and atmospheric conductivities occurring during the eclipse. Therefore, it is important to ascertain the change in aerosol levels, if any, during the solar eclipse.

2 Methodology

The number size distribution measurements of the aerosols were carried out using particle counter (model KC-01A). These were made at a height of about 9m above the ground on second storey of Physics Department, University of Roorkee. The University of Roorkee campus is located in Roorkee town (long. 77^0 53' E, lat. 29^0 52' N and hamsl 269.70 m). The place is not an industrial one and the main manmade activity responsible for the production of aerosols is burning of fossil fuel for household activities and for running the automobiles.

Measurements were made in the past to determine the size distribution of the aerosols having radii greater then 0.2 µm using a cascade impactor on three occasions[6]. The distribution functions are found to follow the power law $[n\ (r) \propto r^{-v}]$, value of the constant v being different at all the occasions but lying in the range, $3 \le v \le 4$, for particles bigger than 0.1 µm. The internal layout of the particle counter used is shown in Fig. 1. The concentration of airborne particles is measured by exposing the particles to light and counting the number of particles by size. Light scattered by airborne particle is converted into a pulse signal by the photomultiplier tube. Since this pulse height value has a given relationship with the quantity of scattered light, this scattered light has a relation to particle sizes. The particles size can be discriminated by the analysis of pulse height value. The particle counter monitors the number concentration in four different size ranges, viz. 0.3-0.5 µm, 0.5-1 µm, 1-2 µm and 2-5 µm, respectively. The observations were taken on the day of the eclipse (24 Oct. 1995) as well as on the preceding (23 Oct. 1995) and succeeding days (25 Oct. 1995) between 0700 and 1200 hrs IST.

3 Results and discussion

Figure 2 shows the variation of the aerosols number concentration (per litre) with local time as measured by the particle counter on three days. It
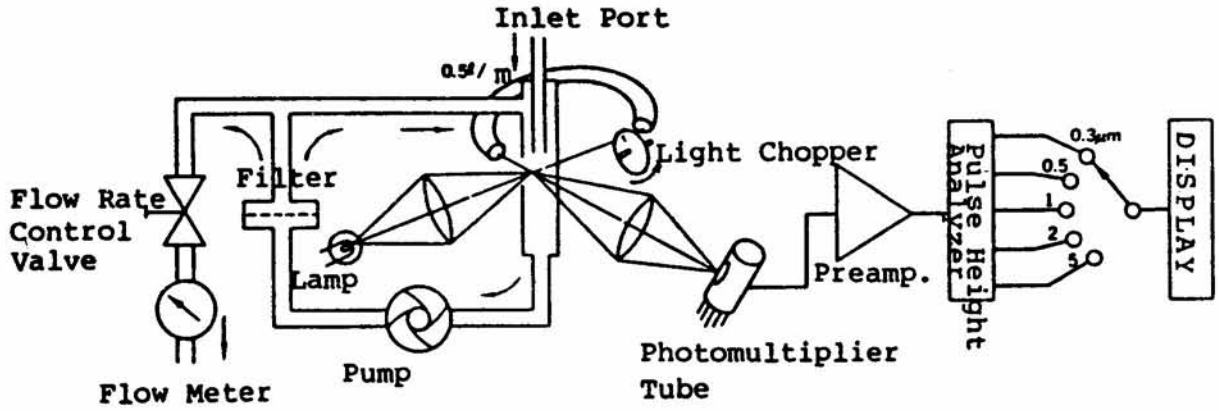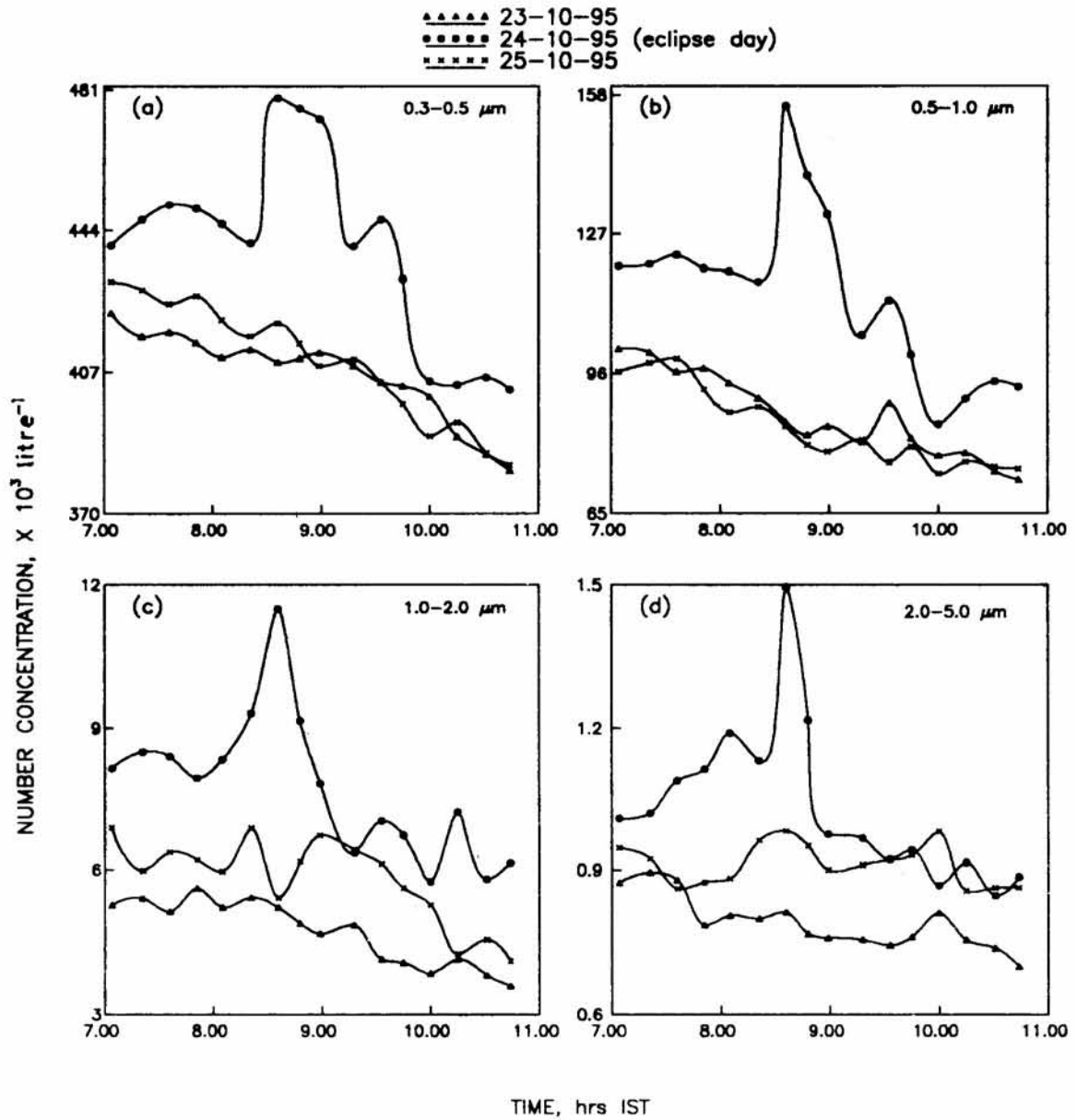
Fig. 1—Internal layout of particle counter

Fig. 2—Variation of particle number concentration in different size groups as monitored by particle counter

is observed that for the particles in size range 0.3-0.5 μm [Fig. 2(a)], the changes are similar on the days preceding and succeeding the eclipse day and indicate a level ranging from 3.8×10^5 to 4.3×10^5 particles per litre. There is a decrease in number concentration as the day progresses with minor peaks and troughs. However, on the eclipse day, the behaviour is distinctly different. There is a considerable increase in aerosol number in comparison with the normal days. However, the aerosol concentration in all the cases of Fig. 2 is higher on eclipse day as compared to the other days even before the onset of the solar eclipse. This increase in aerosol concentration before the eclipse onset has been attributed to the large number of particles thrown into the air by the use of crackers till late in the previous night, because that was the day of Diwali (festival).The most noticeable aspect is the sharp increase to a value of 4.8×10^5 at 0835 hrs IST. This peak is observed 6 min before the centre of the eclipse. After this period, the levels remained higher than those found on the other two days. Similar variations are seen for the particles in size range 0.5-1 μm, 1-2 μm and 2-5 μm [Fig. 2{(b)-(d)}].

The increase in aerosol number concentration during the period of total solar eclipse can be explained on the basis of time variation of the relative humidity and air temperature. The air temperature and humidity profiles for the eclipse day and the next day are shown in Fig. 3 [(a) and (b)]. On the eclipse day, there is a definite lack of warming during the period 0750-0910 hrs IST and the humidity increases from 77% to 87% during the same period. This can lead to condensation effects which manifest an increase in number concentration. The increase in number concentration is due to the shift of very fine undetectable particles into the detection range of the particle counter. Lowering of wind speed and prevailing of calm conditions during the eclipse are the other likely causes of aerosol build-up. The observed increase in particles after a time lag of 70 min is due to the fact that the aerosol behaviour is coupled with several complex atmospheric processes related to the reduction in the solar intensity and consequent cooling.

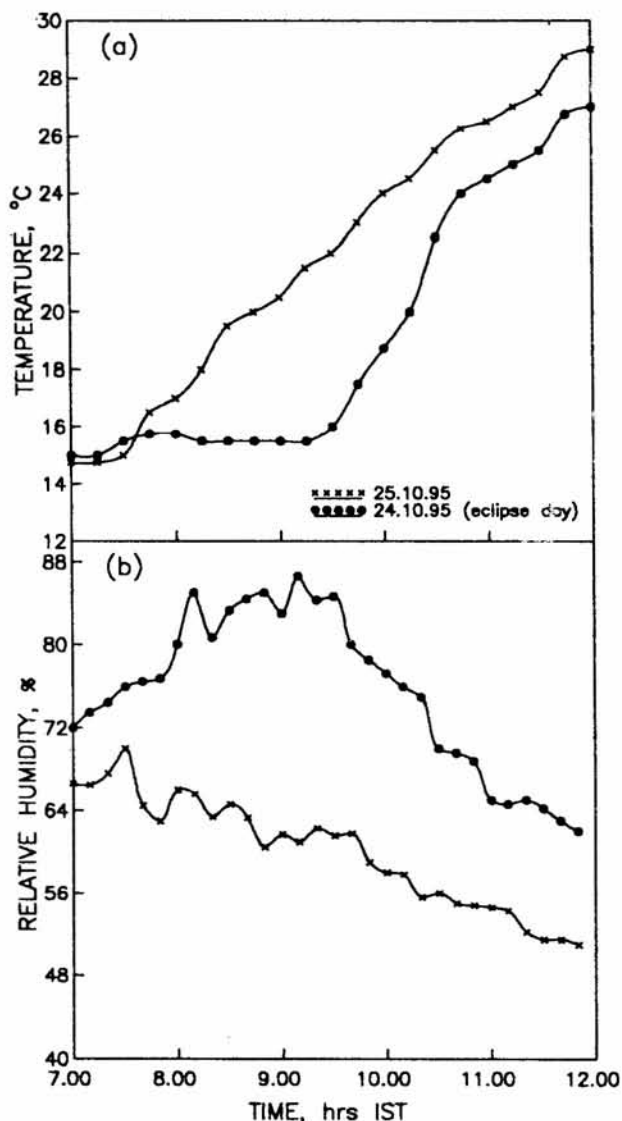## 4 Conclusions

The present study provides data on aerosol

Fig. 3—Temporal variation of (a) air temperature and (b) relative humidity

build-up from direct measurements during solar eclipse. There is an increase in aerosol concentration due to the build-up effect on the day of total solar eclipse. The changes in the temperature and relative humidity during the eclipse are the key to the observed increase. However, the changes in the mass concentration can provide better insight into the aerosol growth due to condensation.

Acknowledgement

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