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Variation of aerosols in relation to some meteorological parameters during different weather conditions

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RESUMEN

Las variaciones de la concentración de aerosoles se han estudiado con respecto a algunos parámetros meteorológicos como la velocidad del viento, la temperatura, la humedad relativa y la precipitación durante el monzón del sureste (junio-septiembre, 1996) e invierno (noviembre, 1996-febrero, 1997) en Roorke. Las mediciones se hicieron con la ayuda de dispersómetros de rayos laser para una gama amplia de tamaño de los aerosoles (0.05-3.0μm). El presente estudio destaca el hecho de que la densidad numérica de los aerosoles está afectada en gran medida por los parámetros meteorológicos. La concentración de aerosoles fue mínima en agosto, septiembre y noviembre, 1996 y permaneció cerca del máximo en junio-julio, 1996 y enero-febrero, 1997. La variación de los aerosoles está en fase con la humedad relativa durante la estación invernal, mientras que está fuera de fase con la temperatura. Su variación con la humedad se explica en función de la condensación que tiene lugar en la atmósfera. Durante el periodo monzónico la lluvia juega un papel muy importante en la caracterización de la densidad del aerosol. La concentración y tamaño de éste se halló disminuida en septiembre, 1996, aunque la humedad relativa fue muy elevada. Se atribuye esto a un barrido de las partículas de aerosol.

ABSTRACT

Variation of aerosol concentration has been studied in the view of some meteorological parameters like wind speed, temperature, relative humidity and rainfall during South-East (SE) monsoon (June-September, 1996) and winter (November 1996-February, 1997) at Roorkee. The measurements were done with the help of laser beam scatterometer for a wide range of size of aerosols (0.05-3.0 μm). The present study brings out the fact that the number density of aerosols is very much affected by the meteorological parameters. The aerosol concentration was minimum in the August, September and November, 1996 and remained around maximum in June-July, 1996 and January-February, 1997. The variation of aerosols is in phase with relative humidity during winter season while it is out of phase with temperature. Its variation with relative humidity has been explained in terms of condensation taking place in the atmosphere. During monsoon period the rain plays very important role in characterizing the aerosol density. The aerosol concentration and size were found to be decreased during September, 1996 although the relative humidity was very high. The credit goes to scavenging of aerosol particles.

1. Introduction

The atmospheric aerosols are produced by variety of processes and are very much important to characterize various lower tropospheric phenomenon. A study on the variation of atmospheric aerosol concentration in relation to their dependence on some meteorological parameters, close to the Earth surface, can greatly help to understand the role of meteorology in the aerosol distribution and vice versa. A clear knowledge of the nature of the size distribution of aerosols at any location is very important not only to characterize the aerosol system over the location but also to study the cloud process (Zuev, 1982), radiative properties (Krishnamurthy, 1988) and effect of warming due to green house gases (Harshvardhan, 1993) of the atmospheric region in which the aerosols are distributed. While such studies have been carried out (Hoppel *et al.*, 1990; Park *et al.*, 1990) at high latitudes, the studies at low latitudes are very rare. Singhal *et al.* (1985) and others hence studied the diurnal, seasonal and annual variations of aerosols at low latitudes.

The atmospheric aerosols are generally hygroscopic, so relative humidity plays very important role to alter the radiative property of aerosols (Parmeswaran and Vizaykumar, 1994). Hanel (1976) studied the changes in aerosol properties as a function of relative humidity. Devara and Raj (1998) has tried to find out some relationship between meteorological parameters and coloumner aerosol distribution. Parmeswaran *et al.* (1995) studied the variation of aerosol optical depth covering the period of June, 1989 to December, 1990 in relation to various meteorological factors like wind speed, rain fall, relative humidity at a coastal station, where sea plays very important role to govern the meteorological process. Hanel and Lehmann (1981) and Shaw (1988) have tried to study the size distribution of atmospheric aerosols in different meteorological conditions.

In the present paper we have tried to study the effect of meteorological parameters on aerosol number density and distribution during disturbed (SE monsoon, 1996) and fair weather (winter, 1996-97) conditions at Roorkee (29°52' N, 77°53' E, 275 meters above the sea level). Roorkee has natural as well as anthropogenic sources for atmospheric particles. Since place is not an industrial one the man made particles are produced only by vehicular traffic and household activities.

Study on aerosol distribution can be done by using various techniques available such as cascade impactor (Pahwa *et al.*, 1994), lidar (Devara and Raj, 1998; McCormick *et al.*, 1978) and low pressure impactor (Parameswaran and Vizaykumar, 1994). For present study we measured the aerosol concentration by using a laser scatterometer (Singh *et al.*, 1999)

2. Methodology

The number density distribution of aerosols was measured by a laser beam scatterometer based on Mie scattering theory with an assumption to log normal distribution of aerosols. The observation have been taken daily between 10 a.m. to 5 p.m. for whole monsoon and winter season at a height of 12 meters from ground surface at Physics Department, University of Roorkee, Roorkee. A laser light (6328 Å) has been used for scattering purpose. The concentration is measured by exposing the particles to laser light and measuring scattering intensities at forward (45°) and backward (135°) scattering positions with the help of phototransistors.

The scattered intensity of light varies with the particle size and their concentration. The size parameter of particles can be determined by comparing the ratio of scattered intensities with the theoretical values of scattered intensities of visible light (Denman *et al.*, 1966). Knowing the size parameter, the size and concentration of aerosol particles for the size range 0.05-3.0μm can be obtained easily.

3. Results and discussion

The observations on meteorological parameters like temperature, wind speed, relative humidity and rainfall and aerosol concentration have been shown in Figures 1 and 4 for the monsoon and winter season respectively. The variation of aerosol concentration with wind speed (WS), average temperature, relative humidity (RH) and rainfall (RF) are shown in Figures 2 and 5.

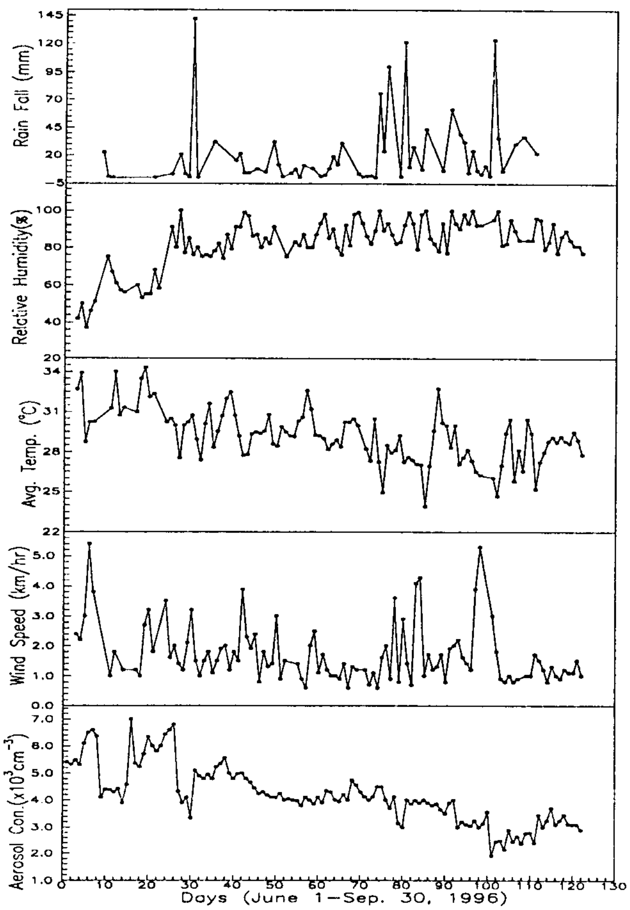

Fig. 1. Variation of aerosol concentration, wind speed, average temperature, relative humidity and rain fall during June-September, 1996.

Also the behavior of mode radius with these parameters has been shown in Figures 3 and 6 respectively for both seasons. Observation of these data shows that the aerosol concentration decreases continuously during monsoon season while RH was minimum in June and was almost constant during July to September, 1996 but having highest values. In the month of June and July the average aerosol concentration was maximum while RH was minimum in these months (Fig. 1). Also concentration varies in phase with temperature and wind speed (Fig. 2). Hanel and Lehmann (1981) and Shaw (1988) suggest that the size distribution of atmospheric aerosols varies significantly with change in temperature and RH. Parameswaran and Vizaykumar (1994) found that the RH does not affect significantly the aerosol concentration and size distribution up to a limit of 95%. Here at Roorkee in the month of August and September, 1996 average RH was almost close to this limit. Devara and Raj (1998) have observed that the higher relative humidity, lower temperature during SW monsoon (1988) at Pune, India caused the growth of cloud droplets which results higher rainfall. The same physical process appears to be happened in 1996 at Roorkee during the SE monsoon. The decrease in aerosol concentration varies in phase with the increasing activity of monsoon. This is attributed to the RF, which was the powerful factor to lower the aerosol concentration involving rain out process.

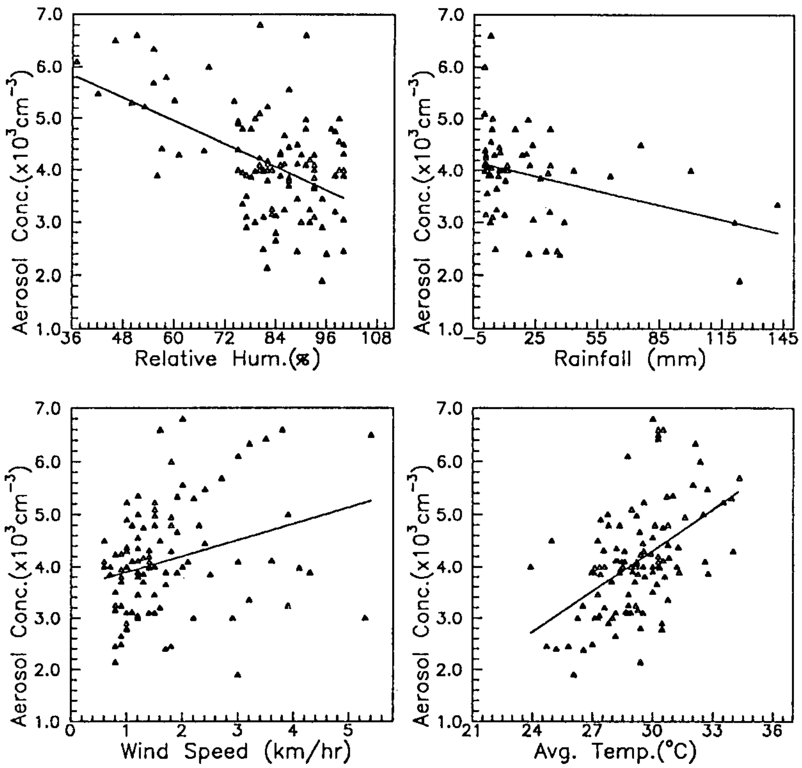

Fig. 2. Variation of aerosol concentration in relation to wind speed, average temperature, relative humidity and rainfall during June-September, 1996.

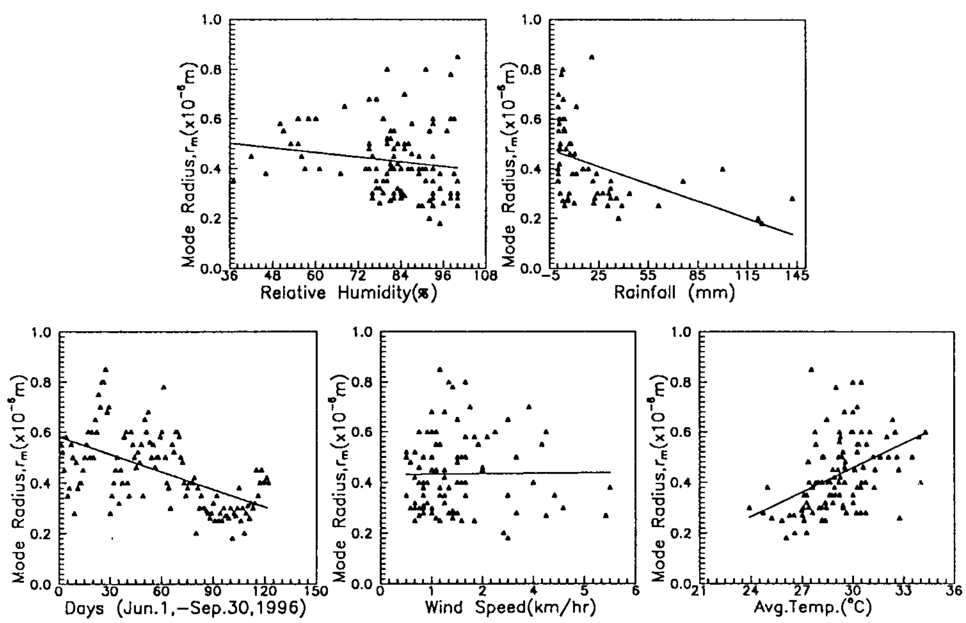

Fig. 3. Variation of mode radius in relation to wind speed, average temperature, relative humidity and rainfall during June-September, 1996.

The mode radius of aerosols decreases continuously during monsoon season. Wind does not play significant role in governing the mode radius while it varies in phase with average temperature and out of phase with RF and RH. Parameswaran and Vijayakumar (1994) have found that the aerosol size distribution remains unaffected by the relative humidity up to a limit of 95%. After this value the mode radius increases with RH. However the finding in this paper is contrary to the work of Parameswaran and Vijayakumar (1994). During monsoon period the aerosols are removed from the atmosphere by scavenging which explains our observations that the mode radius inversely correlated with relative humidity. For other seasons it is not true situation.

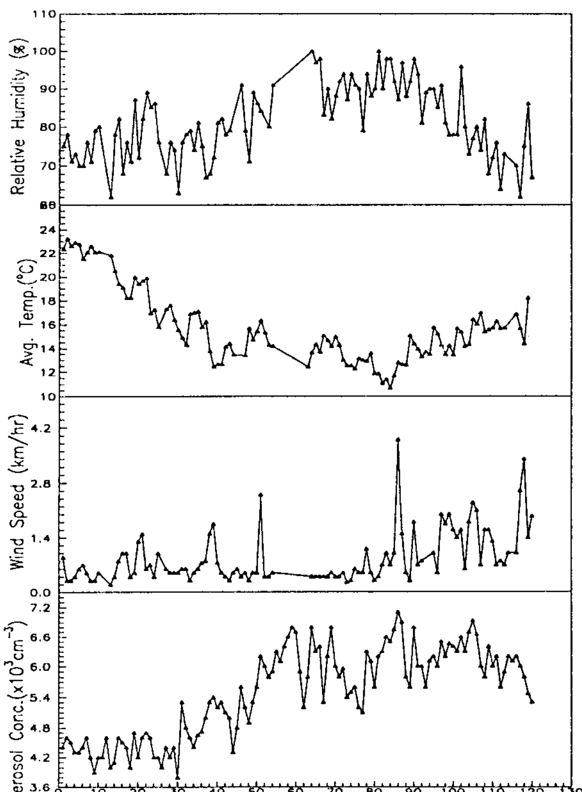

Fig. 4. Variation of aerosol concentration, wind speed, average temperature and relative humidity during November, 1996-February, 1997.

The winter season (November, 1996-February, 1997) at Roorkee was quite different from SE monsoon. The rain does not occurred significantly during this period. Wind also does not play any effective role during first half (November-December, 1996) but varies in phase with the concentration during second half (January-February, 1997, Figs. 4 and 5). The high humidity and low temperature was observed during this season (Fig. 4). The aerosol concentration increases with increase in RH and decrease in temperature. The same is true for mode radius also WS plays important role to governing the mode radius as large number of particles become air-born and hence take part in condensation due to low temperature and high RH. The average value of RH was found to be above 90% during the second half of winter and about 80% during first half. The average temperature touches a minimum of 10°C during January, 1997. The increased mode radius and aerosol concentration is attributed to the growth of particles due to high RH and low temperature during the whole season.

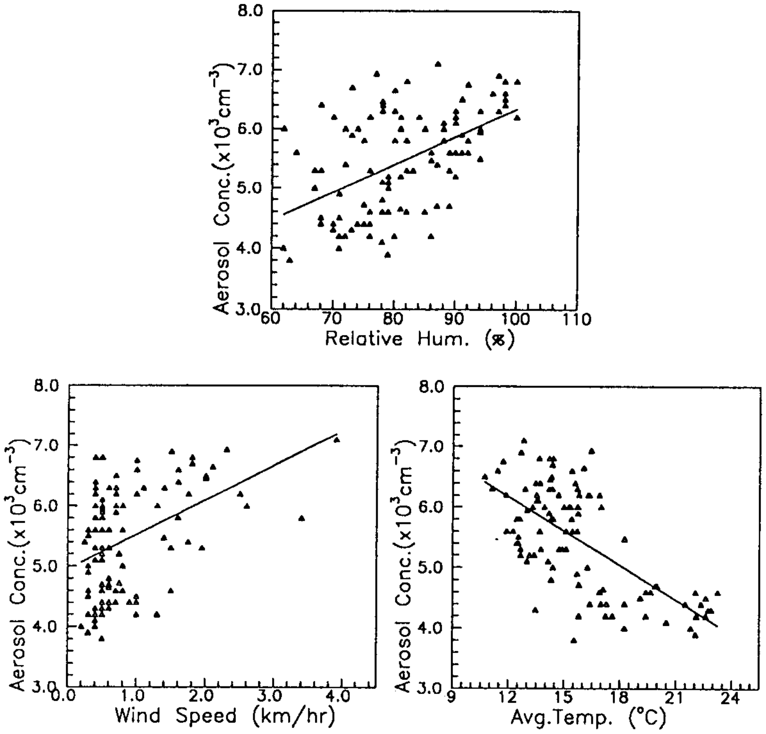

Fig. 5. Variation of aerosol concentration in relation to wind speed, average temperature and relative humidity during November, 1996-February, 1997.

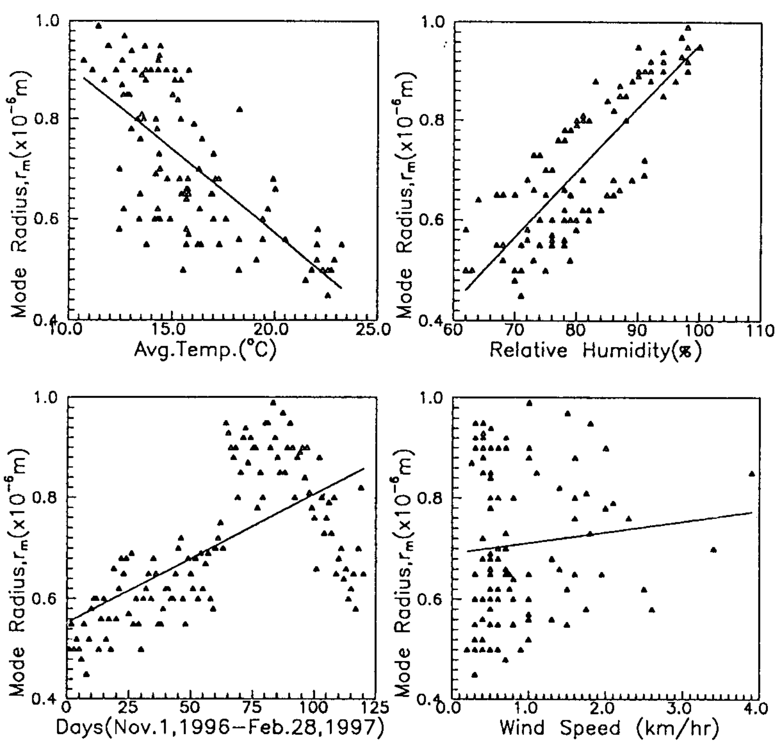

Fig. 6. Variation of mode radius in relation to wind speed, average temperature and relative humidity during November, 1996-February, 1997.

The results indicate a strong correlation between the aerosol number density and size distribution and meteorological parameters in different weather conditions. Although the, observations were taken at Roorkee only, however, the findings are expected to be valid for all subtropical regions.

4. Conclusion

The present study reveals the fact that the aerosol mode radius and number concentration is very much affected by the meteorological factors. The wind speed, relative humidity and temperature play important roles to modulate the aerosol behavior at any location, but large amount of precipitation (heavy monsoon) can alter the number density and size distribution of atmospheric aerosols more efficiently than RH and WS.

REFERENCES

Denman, H. H., W. Heller and W. J. Pangonis, 1966. Angular scattering functions for spheres, University Press, Detroit, USA.

Devara, P. C. S. and P. E. Raj, 1998. A lidar study of atmospheric aerosols during two contrasting monsoon season, *Atmósfera*, **11**, 199-204.

Hanel, G., 1976. The properties of atmospheric aerosol particles as function of relative humidity at thermodynamic equilibrium with the surrounding of moist air, Advances in Geophysics, edited by H.E. Landsberg and J. Van Meighen (Acadmic Press Inc., New York, USA) 19, 73-188.

Hanel, G. and N. Lehmann, 1981. Equilibrium size of aerosol particles and relative humidity: New experimental data from various aerosol types and their treatment for cloud physics applications, Contr. *Atmos. Phys.*, **54**, 57-71.

Harshvardhan, 1993. Aerosol-Climate Interactions, edited by P. V. Hobbs, International Geophysics Series, 54, 75-95.

Hoppel, W. A., J. W. Fitzeraled, G. M. Frick, R. E. Larson and E. J. Mack, 1990. Aerosol size distributions and optical properties found in the marine boundary layer over the Atlantic Ocean, *J. Geophys. Res.*, 95, 3659-3686.

Krishna Murthy, B. V., 1988. Aerosol and radiation budget in the middle atmosphere, *Indian J. Radio Space Phys.*, **17**, 203-219.

McCormick, M. P., T. J. Swissler, W. P. Chu and W. H. Fuller, 1978. Post-volcanic stratospheric aerosol decay as measured by Lidar, *J. Atmos. Sci.*, **35**, 1296-1303.

Pahwa, D. R., S. P. Singhal, and L T. Khemani, 1994. Studies of aerosols at Delhi, *Mausam*, **45**, 1, 49-56.

Parameswaran, K., G. Vizaykumar, B. V. Krishna Murthy and K. Krishna Moorthy, 1995. Effect of wind speed on mixing region aerosol concentration at a tropical coastal station, *J. App. Meteor.*, **34**, 1392-1397.

Parameswaran, K. and G. Vizaykumar, 1994. Effect of atmospheric relative humidity on aerosol size distribution, *Indian J. Radio Space Phys.*, **23**, 175-188.

Park, P. M., M. H. Smith and H. J. Exton, 1990. The effect of mixing height on maritime aerosol concentration over the North Atlantic Ocean, *Quart. J. Roy. Meteor. Soc.*, **116**, 461-476.

Shaw, G. E., 1988. Aerosol-size temperature relationship, *Geophys. Res. Lett.*, **15**, 133-135.

Singh, A. K., S. Niwas, A. Kumar, J. Rai and M. J. Nigam, 1999. Variations in atmospheric aerosols and electrical conductivity at Roorkee during the total solar eclipse of October 1995, *Indian J. Radio Space Phys.*, **28**, 1-10.

Singhal, S. P., S. K. Agarwal, D. R. Pahwa and B. S. Gera, 1985. Stability studies with the help of acousting sounding, *Atmos. Environ.*, **19**, 221-228.

Zuev, V. E., 1982. Laser beams in the atmosphere, Plenum Publishing, New York, USA.