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VERTICAL DISTRIBUTION OF ATMOSPHERIC AEROSOLS IN THE LOWER TROPOSPHERE OVER TRIVANDRUM

Bijoy V. Thampi, Manoj K. Mishra, K. Parameswaran, Korak Saha, C. Suresh Raju, K. Rajeev

Space Physics Laboratory, Vikram Sarabhai Space Centre, Trivandrum 695 022
E-Mail: k_parameswaran@vssc.gov.in

Introduction

Most of the primary sources of atmospheric aerosols are located at the earth's surface. Convection and turbulent eddies transport these aerosols vertically to higher altitudes, where the residence time is sufficiently large which favours transport of these aerosols horizontally for long distances. This process, however, critically depends on the state of the atmospheric boundary layer, which undergoes a very prominent diurnal variation. Convective eddies which are mostly prevalent during the daytime ceases after the sunset and gives way to a relatively stable nocturnal boundary layer. This reduces the mixing height during the nighttime. Over the coast, the sea breeze and land breeze cells further modulate the circulation in the boundary layer. Aerosols lifted up by the convective eddies to higher altitudes during the day could persist for some time because of the prevailing neutral condition during early night hours. Earlier studies (cf., Parameswaran et al., 1997), however, suggest that though the mixing height of aerosols in the nocturnal atmospheric boundary layer (NABL) decreases as the night progresses, accretion of aerosols can occur in the stable atmosphere sandwiched between stratified turbulent layers. The main purpose of this study is to understand the temporal evolution of the vertical distribution of aerosols in the lower troposphere (up to ~2.5 km) during the dry season (February-April) at Trivandrum (8.5^{o}N, 77^{o}E) when the annual variation of aerosol optical depth (AOD) also reaches its peak value.

Experimental setup

The altitude profiles of aerosol number density (Na) are obtained from the bistatic Continuous Wave Lidar (CWL) system operating at a laser wavelength of 514.5 nm. The system consists of a CW laser transmitter (transmitted power of 500 mW) and a transmission type receiver telescope (diameter of 300 mm), which are separated by a distance of 380 m in the same horizontal plane. The system measures the intensity of the scattered radiation from different altitudes on suitably orienting the transmitter and receiver elevations, which is used to construct the altitude profile of aerosols number density. It takes nearly 45 minutes to get one full profile up to ~2 km. The vertical resolution of the data decreases with altitude from ~50 m at 250 m to ~650 m at 1700 m. The details of the system, the observation geometry, and the inversion of CW Lidar data to derive altitude profile of Na are described in Parameswaran et al. (1984). A modified power law type aerosol size distribution with size index 4.5 and aerosol refractive index of 1.45 are used for this inversion. The system is operated on clear nights from 1930 to 0515 IST. Observations are not carried out when clouds are present over the observation site. Based on the phase of the moon and cloud conditions, observations are carried out on five nights in each month.

Results and Discussion

Aerosol mixing height in NABL

Figure 1 shows the altitude profiles of Na at different times during the night of 13th March 2007. Due to the presence of clouds, the observations could be started only around 2300 IST on this night. The aerosol mixing height (Hm) is calculated from the vertical gradient of normalized aerosol concentration (NCG) as "the height near the surface where NCG has a maximum positive value and continues to remain negative above this level". Note that in the first two profiles, Na increases with increase in altitude to reach its peak value at ~550 m followed by a steady decrease above. As seen from Fig.1, the mixing height was ~500 m up to ~0000 IST. The profile during 0100 IST was also somewhat similar to that before, except for a small reduction in Na and the mixing height. This reduction in Hm and the vertical gradient in Na near the mixing height became more remarkable in subsequent profiles and the value of Hm decreased below 300 m in the early morning hours. Similar features were observed on two subsequent nights also.

During all the three months of observation (February, March, April 2007), the mixing height in the early part of the night was in the range of 420 to 500 m, and significant reduction in mixing height was observed between 2200 and 0100 IST. This indicates that the aerosol mixing height and the aerosol concentration in the residual layer do not change drastically even though the convective eddies ceases soon after the sunset. The response time appears to be around 4-6 hrs after the sunset.

Enhanced aerosol layers in the lower troposphere

Though the aerosol number density, in general, showed a marked decrease above the mixing height, frequently this decrease is confined to <200 m above the mixing height. It is also observed that in a few cases this decrease is almost insignificant and at times an enhanced layer of aerosols is also observed between 600 to 1600 m. While this layer was rather weak during 13th March 2007 (Fig.1), it is very prominent during some other nights. A typical example is shown in Fig. 2 for 19th April 2007. The altitude of the peak increased from 850 m at 2030 IST to 1200 m at 2330 IST followed by a decrease to 700 m by 0430 IST. The value of Na associated with this secondary peak was often comparable to or more than that corresponding to the peak near the mixing height. High concentration of aerosols and large altitudinal extent of this layer as well as its persistence throughout the night indicates that this could be associated with a synoptic scale transport rather than of local origin.

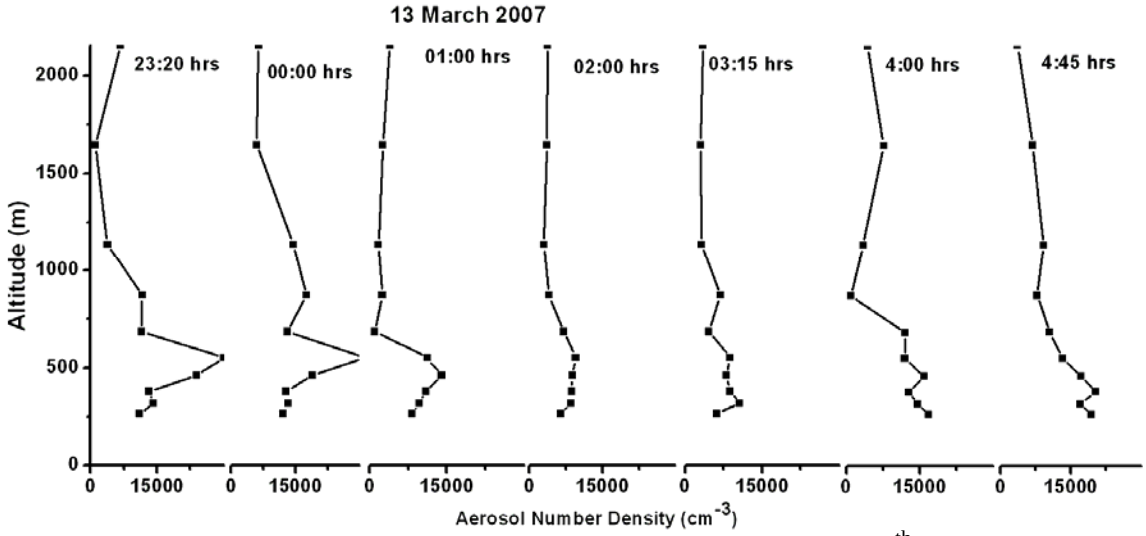

Figure 1. Altitude profiles of Na at different times during the night of 13th March 2007.

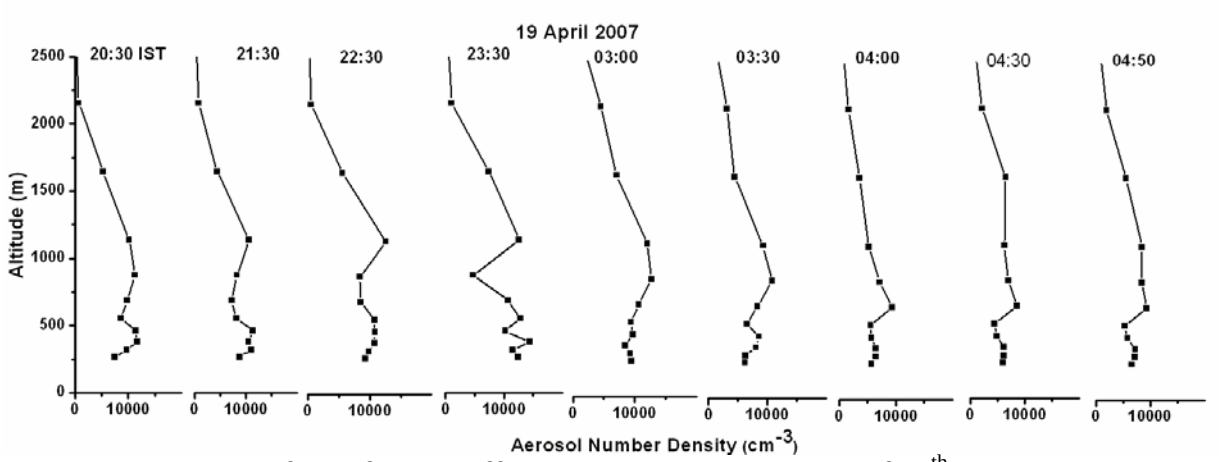

Figure 2: Altitude profiles of Na at different times during the night of 19th April 2007.

Conclusions

Temporal variations in the vertical distribution of atmospheric aerosols in the nocturnal atmospheric boundary layer and the lower troposphere during the later part of Asian dry season (February-April) are investigated over the coastal station, Trivandrum. This study showed that a significant decrease in aerosol mixing height occurs 4 - 6 hours after the sunset. The time scales associated with changes in the vertical structure is very small during this period. The nocturnal mixing height which is around 420-500 m during the early night hours decrease to <300 m during the early morning hours. Frequently, a prominent layer of enhanced aerosol concentration, persisting throughout the night, is observed in the altitude region 600 – 1600 m. The total aerosol content of this layer is often more than that in the well mixed region which could mostly be due to synoptic scale features rather than of local origin.

References

1. Parameswaran, K., K. O. Rose, and B. V. Krishna Murthy, Aerosol characteristics from bistatic lidar observations, J. Geophys. Res., 89, 2541-2552, 1984.
2. Parameswaran K, Rajeev K and Sen Gupta K, An observational study of night time aerosol concentration in the lower atmosphere at a tropical coastal station; *J. Atmos. Terr. Phys.* **59,** 1727-1737, 1997.