EPJ Web of Conferences **119**, 23012 (2016) DOI: 10.1051/epjconf/201611923012
ILRC 27

AEROSOL OPTICAL PROPERTIES IN THE LOWER TROPOSPHERE DURING SUMMER OVER NEW DELHI

Radhakrishnan Soman Radha*, Bhuwan Chandra Arya, Sumith Kumar Misra, Chhemendra Sharma, Arun Kumar, Devesh Kumar Shukla and Jaswanth

*CSIR-National Physical Laboratory, Dr.K.S.Krishnan Road, New Delhi, India, *E-mail: rkrishnan@nplindia.org*

ABSTRACT

This work reports the variation in optical properties of aerosol in the boundary layer over the Delhi region during the summer season of the year 2014. The layering of aerosol particles in the shallow residual layer is observed in the night preceded by the hot days. The monitoring of this kind of layers in the lower troposphere is very important to study its long range transport.

1. INTRODUCTION

Aerosols play an important role in the radiation budget of Earth's atmospheric system through direct, indirect and semi direct effects. Altitude distribution of aerosols is an important factor which influences in many way the weather and climate of the Earth-atmosphere system. Atmospheric residence time as well as long-range transport of aerosols is primarily governed by the altitude distribution. The microphysical and optical properties and vertical distribution of aerosols are needed to be measured to understand their influence on radiative forcing [1].

The aerosol loading over the north Indian region is found to be increasing compared to the southern part [2]. The mega city Delhi situated in the western part of Indo Gangetic Basin (IGB) in the north Indian region experiences extreme weather conditions every year. Also it experiences the dust storm events during summer, haze and fog during winter, anthropogenic loading of aerosols associated with festivals and biomass burning etc. The increasing industrialization/urbanization and population growth are also one of the causes of loading of aerosols. Dubey et al., [3] reported vertical distribution of aerosol and clouds over New Delhi using Micropulse lidar observations.

During summer the surface heating and the result of increase in convection over land enhances the aerosol concentration in the boundary layer. The frequent dust storm activities also contribute largely to the increase in coarse mode particles during the summer season. This work reports the variation in boundary layer aerosol optical properties over the urban tropical region Delhi during summer 2014. The variation in optical properties of aerosols in the boundary layer during the May-June (summer) period of the year 2014 is studied.

2. DETAILS OF THE LIDAR SYSTEM AND METHOD OF ANALYSIS

A dual polarization micropulse lidar system is developed indigenously to study the boundary layer aerosols and clouds. This lidar uses the diode pumped Nd:YAG microchip laser as source that emits a pulse of duration of 750 ps at 532 nm wavelength with energy of 3 µJ and repetition rate of 7.1 kz. The backscattered signal is collected using a 20cm Cassegrain telescope and split into co-polarized (p) and cross polarized (s) signals using beam splitter. A single photomultiplier is using for near simultaneous measurement of the **p** and **s** signals with a stepper motor controlled mirror system. Number of photons are counted using photon counter and stored in the memory of the computer for further analysis. All the steps of the data acquisition, online display of the data etc. are controlled through the indigenously developed control software. The details of the lidar system can be seen elsewhere [3]. For the current study each lidar profile obtained during night time with a range resolution of 24 m and integrated for 10,000 laser pulses is used. Then, spatial and temporal averaging is done for better signal-to-noise ratio and then noise removed and range corrected for further analysis. Fernald's [4] algorithm is used to obtain the aerosol backscatter coefficient from the lidar signal. The lidar data obtained during night time for the period of May-June of the year 2014 is used for this study.

3. RESULTS AND DISCUSSION

During the months of May and June of the year 2014 Delhi experiences record heat and a severe storm event. The daily maximum and minimum temperature, relative humidity, wind velocity and average rainfall during May and June are shown in Figure 1.

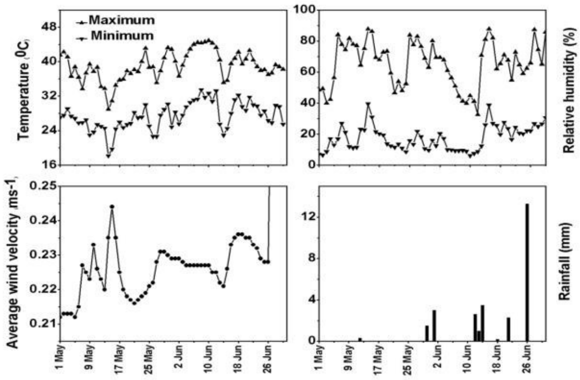

Figure 1: Daily Maximum and minimum temperature, relative humidity, wind velocity and average rainfall during May and June of the year 2014.

In most of the days during the month of June the maximum temperature was above 37 ^{0}C and in the month of June it was above 40 ^{0}C. The minimum temperature also was very high (>24 ^{0}C) during May and June. The relative humidity varies between 25 and 45 % during the observation period. The wind velocity was moderate during the observation period except the dust storm day. Some days of June there was showers. But not much change in the surface temperature was observed on or after the shower.

The variations in the boundary layer aerosol optical properties are derived from the backscattered lidar signal for the months of May and June. For convenience ground (0.072 km) to 2 km altitude range is divided into two slab thicknesses namely slab1 (0.072 to 1km) and slab2 (1km to 2km). The integrated aerosol backscatter coefficient (IABC) corresponds to a slab is obtained by integrating the aerosol backscatter coefficient from base to top of that slab.

The daily mean values of the IABC for the 0.072 to 1 km and 1 to 2 km range obtained during the observation period is shown in Figure 2.

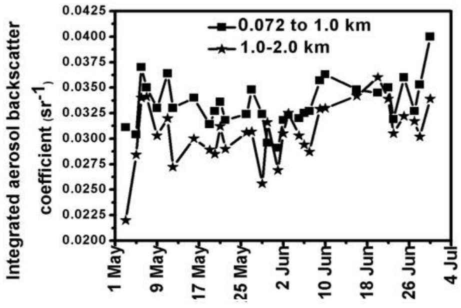

Figure 2: Integrated aerosol backscatter coefficient (sr^{-1}) during the May-June period of the year 2014.

In most of the days during the observation period the value of IABC in the 0.072 to 1 km (slab1) is comparatively higher than its value in the 1 to 2km (slab2) range. In few cases IABC in the 1-2 km slightly higher or very close to its values in the 0.072 to 1km. This was observed during the month of June in which the maximum surface temperature was above 40 ^{0}C. During summer, the strong surface convection due to high temperature and low pressure results in deep atmospheric boundary layer (ABL) and accumulation of aerosol particles in the ABL. In the evening the surface cools due to radiative cooling and a stable nocturnal boundary layer forms. The layering of aerosol particles in the shallow residual layer formed in the night time may be the reason for the observed higher aerosol backscatter coefficient during the hot days.

On 30th May 2014 Delhi was hit by a huge dust storm around 1700 hrs. The day time temperature was very high (43^{0}C) and atmosphere was hazy. Figure 3 shows the aerosol backscatter coefficient (derived by lidar) and Microtop derived aerosol optical depth during May 29 to June 2, 2014. Microtop derived AOD values in all wavelength are high on May 30th.

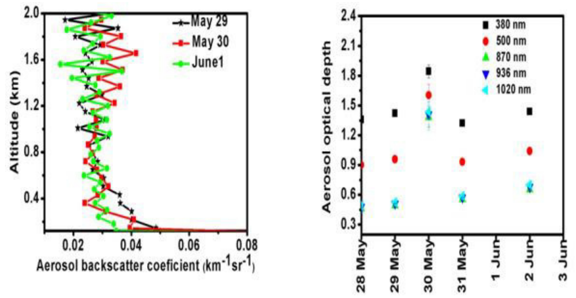

Figure 3: Altitude profile of aerosol backscatter coefficient ($km^{-1}sr^{-1}$) and Microtop derived aerosol optical depth during May 29 to June 2 of the year 2014.

This may be due to the presence of course mode particles present during this period and it is confirmed by the low value of α (an indicator of aerosol particle size). The lidar derived aerosol backscatter profile shows high values on May 29th as compared to May 30th. After the dust storm there was rain and the aerosol particle concentration might have reduced due to washout. Also the aerosol particles in the lower altitude might have transported away from the observation site due to the heavy wind.

4. CONCLUSION

The aerosol variability in the 0.072 to 2 km altitude range over the Delhi region in the summer season of the year 2014 is studied using lidar. The residual layer of aerosol contributes the enhanced backscatter coefficient in the 1-2km altitude range. The monitoring of the vertical profiles of aerosols in the lower troposphere is very useful to study its long range transport.

ACKNOWLEDGEMENT

The authors are thankful to Director NPL and Head-RASD for their consistent support to the ongoing work. Authors also acknowledge CSIR Network Project AIM_IGPHim (PSC-0112) for the financial support.

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