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STUDIES ON AEROSOL OPTICAL PROPERTIES AT HIGH ALTITUDE STATION IN WESTERN HIMALAYAS USING RAMAN LIDAR

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ABSTRACT

The aerosol optical properties have been investigated using the Raman lidar system for the month of November 2018 at the western Himalayan station of Palampur. Before deriving the optical properties, the lidar data has been applied with initial pre-processing such as Dead time correction, atmospheric noise correction, temporal and spatial averaging, range correction, gluing etc. The optical properties such as backscatter coefficient, extinction coefficient and linear depolarization ratio have been derived by using the inversion algorithm proposed by Fernald. The results show that the backscatter coefficient was found in the range from 9.00E-9 $m^{-1}sr^{-1}$ to 4.97E-6 $m^{-1}sr^{-1}$ and the extinction coefficient was found in the range from 3.16E-7m^{-1} to 1.74E-4m^{-1}. The Linear depolarization ratio was in the range from 0.0179 to 0.621 with lower values at near heights suggesting the dominance of spherical particles at the lower heights. We have also observed a cloud layer at a height of 9.5 km to 12.1 km with high depolarization ratio during the observation period on 22/11/2018.

1. INTRODUCTION

The effects of atmospheric aerosols on climate have large uncertainties including their direct and indirect effects related to aerosol-cloud interactions. The climatic effects of aerosol depend on its physical, chemical and optical properties along with its vertical distribution. This enables the need of advanced lidar systems which can provide the optical and microphysical properties of aerosols with its vertical distribution [1].

In India, only few measurements of aerosol vertical profiles by lidar have been carried out. Long-term measurements and continuous measurements of aerosol vertical distribution are even less. In this paper, we are presenting the measurement of aerosol vertical profiles in Palampur, Himachal Pradesh, India. The measurements are based on a Raman lidar which provides information on the vertical distribution of optical presence of aerosols and clouds. [2]

2. METHODOLOGY

2.1 Sampling Site

A Raymetrics Raman Lidar system, LR111-D200 is installed at the National Physical Laboratory's remote monitoring station at the campus of CSIR-Institute of Himalayan Bioresource Technology (IHBT), Palampur, Himachal Pradesh, India at an altitude of 1347 m above mean sea level to study the vertical profiles of physical and optical properties of aerosols and clouds. Palampur is located in the lower Himalayan region of Western Himalayas and lies within the latitude 32.1109° N and longitude 76.5363° E. Figure 1 shows the topographic map of Palampur. It is the first ground based lidar facility in the Western Himalayan region of India.

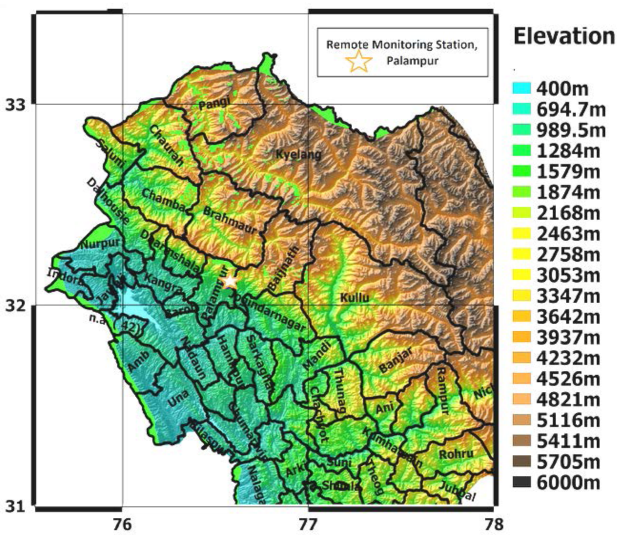

Figure 1: Topographic map of Palampur

2.2 The Lidar System

This lidar system is operated at 355 nm with Raman channel at 387 nm having a spatial resolution of 7.5 m. The return signal is analyzed by using the software provided by the manufacturer for further processing. The co-polarized and cross polarized Mie channels of the lidar system provides the linear depolarization ratio which is an indicator of the shape of the aerosol/cloud particle. The nitrogen Raman channel at 387 nm of the lidar system can be used to derive the lidar ratio, which is an important parameter for the identification of different types of aerosols in the troposphere. The technical specifications of the Raman lidar system are given in Table 1.

Table 1: Specifications of Raman Lidar	
Pulsed Laser Source	Nd:YAG (Quantel ULTRA100 Series)
Wavelength	355 nm
Energy / Pulse	32.8 mJ
Repetition Rate	20 Hz
Pulse Width	5.60 nsec
Laser Beam Divergence	<0.8 mrad
Telescope Type	Cassegrain
Primary Diameter	200 mm
Secondary Diameter	48 mm
Transmitter–Receiver Distance	212 mm
Field of View	2.3 mrad (adjustable from 0.5 to 3mrad)
Detectors	3 PMTs
Data Acquisition Mode	Both Analog and Photon Counting

2.3 Lidar Data Analysis

The Raman lidar data for the 22nd November 2018 has been used for the study. The depolarisation ratio of the lidar system allows us to separate spherical particles from non-spherical. The lidar ratio gives us information about the properties and origin of particles by giving the ratio of the extinction and backscatter coefficient [2]. The Palampur has a very clear environment with very less anthropogenic activities, so a lidar ratio of 35sr has been taken at 355nm [6]. Before deriving optical properties from the raw lidar data, it has been temporally and spatially averaged. Other than this, the raw lidar data has been preprocessed with other corrections such as dead time correction of photon counting (PC) signal, background correction, bin shift correction, range correction, gluing etc. by the software provided by manufacturer. Figures 2 & 3 shows the aerosol backscatter coefficient, extinction coefficient and linear depolarization ratio at 355 nm wavelength for 22nd Nov. 2018.

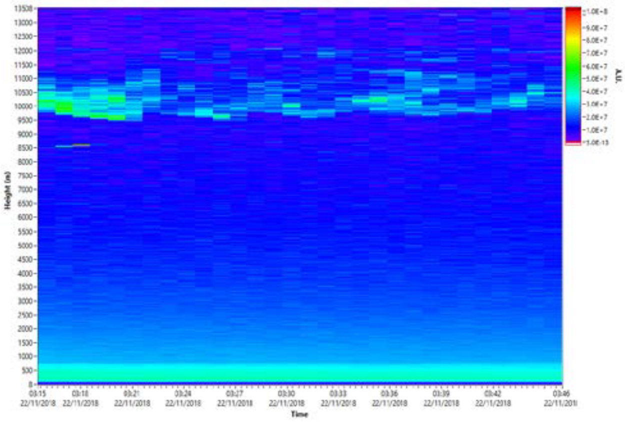

Figure 2 shows the temporal variation of Range Corrected Signal for 22nd November 2018

The figure 2 shows the temporal variation of range corrected signal (RCS) of 22nd November 2018. In this figure, we can see that there is high loading of aerosol over the Lidar station upto 1km and at height of 10-12km we can observe the clouds.

The backscatter coefficient was found in the range from 3.62E-8 $m^{-1}sr^{-1}$ to 1.76E-6 $m^{-1}sr^{-1}$ in low altitude and 9.00E-9 $m^{-1}sr^{-1}$ to 4.97E-6 $m^{-1}sr^{-1}$ in high altitude (9500m-12100m). The extinction coefficient was found in the range from 1.27E-6 m^{-1} to 6.15E-5 m^{-1} in low altitude (upto 800m) and 3.16E-7 m^{-1} to 1.74E-4 m^{-1} in high altitude (9500m-12100m). The value of the backscatter coefficient and extinction coefficient were high near the ground (0-1km) and then it decreased with the altitude. Figure 3 shows that beyond 1000 meters there were very few aerosols and the atmosphere can be considered clear.

The Linear depolarization ratio was in the range from 0.0179 to 0.621. The depolarization values were close to zero at the lower heights suggesting the dominance of spherical particles at the lower heights. We have also observed a cloud layer at a height of 9500m-12100m with high depolarization ratio.

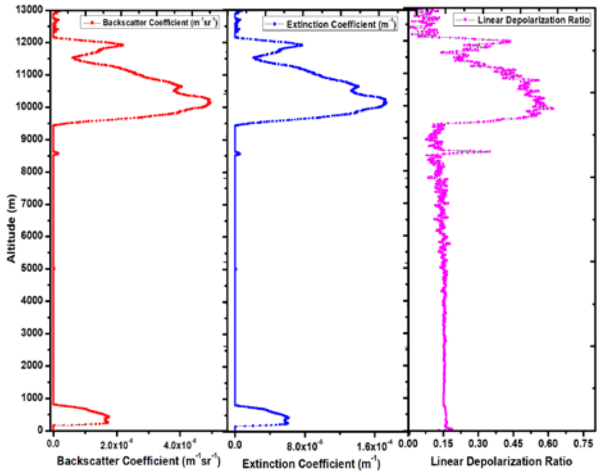

Figure 3 shows the backscatter coefficient, extinction coefficient and linear depolarization ratio of 22nd November 2018.

To trace the sources of air parcel, we have also plotted the HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory) 3 days Back Trajectory for at three different levels, 500m agl (above ground level), 6000 m agl and 13000 m agl in figure 4.

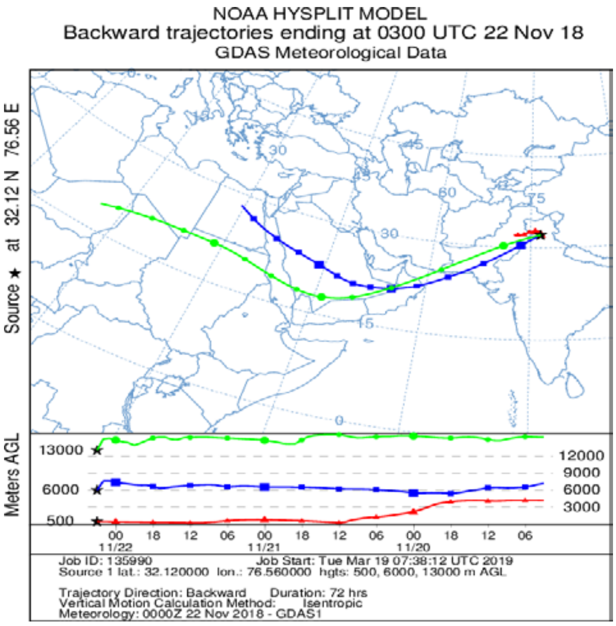

Figure 4 shows three-day backward trajectory by NOAA HYSPLIT

Results show that most of the aerosol loading was due to regional emissions at lower heights of the station. The air parcel arrived at the higher heights of station was from Africa and the western region of the India. This also shows that the cloud loading at higher altitude was originated from the north of Africa having high depolarization ratio.

4. CONCLUSION

The aerosol optical properties over a western Himalayan region Palampur have been investigated by a Raman lidar system for the month November 2018. The raw lidar signal has been pre-processed before deriving optical properties from it. The results show that the aerosol loading was high at the lower heights with the dominance of the spherical particles. A cloud layer was also observed at the height of 9.5 km to 12 km above the ground level.

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REFERENCES

[1] M. Komppula et al. Atmos. Chem. Phys., 12, 4513-4524 (2012).
[2] M. N. Young et al. Atmospheric Research 86, 76–87 (2007)
[3] F. G. Fernald Appl. Opt. 23, 652-653 (1984)
[4] A. Ansmann et al. Optics Letter Vol. 15, Issue 13, 746-748 (1990)
[5] A. Ansmann et al. Applied Physics B 55(1): 18-28 1 (1992)
[6] K. Sasson et al. Geophysical Research Letters, Vol. 34, L08803 (2007)