ULTRAVIOLET HIGH-SPECTRAL RESOLUTION LIDAR FOR MEASURING ATMOSPHERIC OPTICAL PARAMETERS OF AEROSOLS AND CLOUDS

Yuji Iwasaki, Masaharu Imaki, Takao Kobayashi

Graduate School of Engineering, University of Fukui, 3-9-1 Bunkyo, Fukui, 910-8507 JAPAN
yiwasaki@optele.fuee.fukui-u.ac.jp

ABSTRACT

The ultraviolet high-spectral resolution lidar has been developed for measuring atmospheric optical parameters such as extinction coefficient, backscattering coefficient, and lidar ratio of aerosols and clouds. Measurements of the extinction coefficient and lidar ratio were realized in the case of clear atmosphere and Asian dust aerosols.

1. INTRODUCTION

The atmospheric optical parameters such as extinction coefficient and lidar ratio of aerosols and clouds are useful for analyzing the influence on heat balance of the earth in relating with global warming issue. For measuring the atmospheric optical parameters, several lidar schemes have been reported such as the Mie lidar, Raman lidar and high - spectral - resolution lidar (HSRL) [1] - [5].

The HSRL was developed using a single-frequency laser and a narrow bandwidth filter for separately detecting the Mie and Rayleigh scattering signal and the system is the highly sensitive because of a larger Rayleigh cross-section than Raman cross-section. Furthermore, the measurement of absolute value can be realized without assuming the backscatter models unlike the Mie lidar.

We have developed the UV-HSRL system [6], [7] and several atmospheric optical parameters were measured. In this paper, comparison of the extinction coefficient and lidar ratio data are reported for clear air and Asia dust particles.

2. UV-HSRL SYSTEM

Schematic diagram of an UV-HSRL lidar system is shown in Fig.1. The single-frequency ultraviolet third harmonic at 355 nm of the injection seeded Nd:YAG laser is used. Laser pulse energy is 150 mJ with pulse repetition of 20 Hz and the laser beam diameter is enlarged to 60 mm by the beam expander. The received power of the system using ultraviolet wavelength is higher than visible wavelength because the Rayleigh scattering power varies inversely with the forth power of the laser wavelength. In addition, the ultraviolet wavelength has high eye-safety characteristics compared with the visible wavelength.

Backscatter signal is collected by the 250 mm diameter Schmidt Cassegrainian telescope and focused into the 100 µm core multimode optical fiber. The fiber output is collimated and detected by two-photomultiplier tubes (PMTs). The PMT-1 is used for the Mie scattering detection and the PMT-2 is used for the total scattering power detection. Figure 2 shows the Mie and Rayleigh scattering spectrum and filter transmittance function. The Fabry-Perot interference filter is used mainly for transmitting the Mie scattering signal. Using high - spectral - resolution technique, the Mie and Rayleigh scattering power is separated.

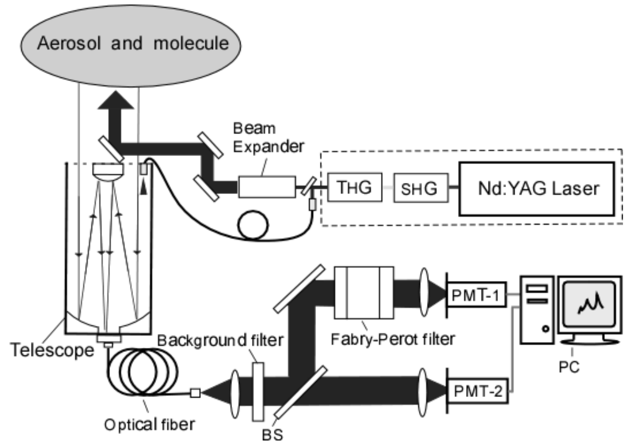


Fig. 1 Schematic of the UV-HSRL system.

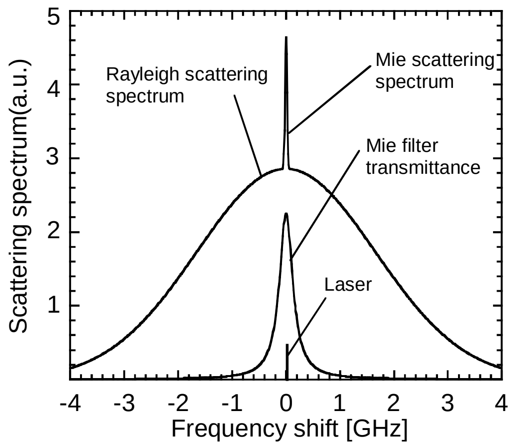
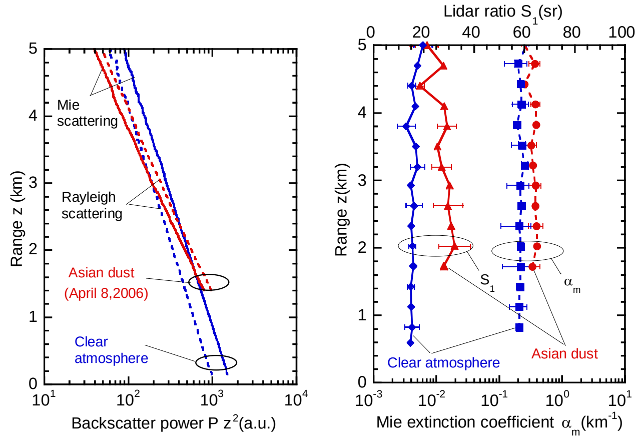


Fig. 2 Spectral profiles of the Mie and Rayleigh scattering and the filter transmittance function.

The extinction coefficient of the aerosol and cloud is derived from the slope of the range profile of the Rayleigh backscatter power. The accurate Mie scattering power is obtained by subtracting the Rayleigh scattering power introduced in the Mie-detector power. From these processes, absolute value measurements are possible without assuming special aerosol models as used in Klett's inversion technique of the Mie lidar.

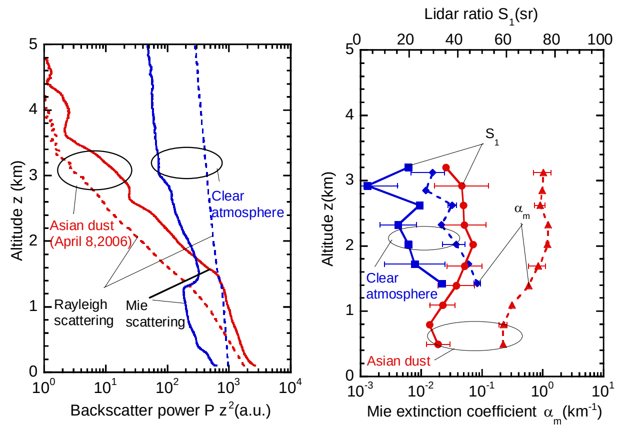
3. EXPERIMENTAL RESULTS

The Mie extinction coefficient and lidar ratio was measured in the case of clear atmosphere and Asian dust condition.



(a) Mie P_M and Rayleigh P_R power. (b) Extinction coefficient α_m and lidar ratio S_1.

Fig. 3 Horizontal range distribution of the return signal and atmospheric optical parameters observed with averaged over 15 min. (a) is the range corrected Mie and Rayleigh backscatter power with 50 m range resolution and (b) is the extinction coefficient and lidar ratio with 300 m range resolution.



(a) Mie P_M and Rayleigh P_R power. (b) Extinction coefficient α_m and lidar ratio S_1.

Fig. 4 Height distribution of the return signal and atmospheric optical parameters observed with averaged over 15 min. (a) is the range corrected Mie and Rayleigh backscatter power with 50 m range resolution and (b) is the extinction coefficient and lidar ratio with 300 m range resolution.

Figure 3 shows the horizontal distribution of the Mie and Rayleigh scattering power, extinction coefficient and lidar ratio. Uniform distribution of extinction coefficient and lidar ratio was observed and the accuracies were 0.03 km^{-1} and 1.4 sr in clear atmospheric condition and 0.08 km^{-1} and 8.8 sr in the case of Asian dust at 3 km range, respectively. It is seen from these results that the uniform characteristics of particle size and species was observed in horizontal direction.

The height distribution of the Mie and Rayleigh scattering power, extinction coefficient and lidar ratio are shown in Fig. 4. The height dependence on the lidar ratio was observed and it is seen that the Asian dust distributed above 1.4 km altitude and clear air aerosol in lower altitude.

4. CONCLUSIONS

The ultraviolet high-spectral resolution lidar has been developed for measuring the atmospheric optical parameters. The horizontal and vertical profiles of the extinction coefficient and lidar ratio were shown in the case of clear atmosphere and Asian dust condition. The result shows difference in the extinction coefficient and lidar ratio.

In future, the experiment research on the relationship between lidar ratio and size and/or species of the aerosol particles will be carried out using this UV-HSRL system.

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