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EYE-SAFE COMPACT MIE SCATTERING LIDAR FOR MEASURING THE ATMOSPHERIC BOUNDARY LAYER

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INTRODUCTION

Measurement of the structure of the atmospheric boundary layer is essentially important for understanding the urban air pollution phenomena. A Mie scattering lidar is an effective tool for visualize the atmospheric structures, and there have been many previous studies on boundary layer measurements. We consider it is practically useful to construct a network of compact lidars for routine monitoring of the boundary layer structure over an urban area. For this purpose, we have been developing an eye-safe Mie scattering lidar using a low pulse energy diode laser pumped Nd:YAG laser.

LIDAR SYSTEM

The parameters of the lidar system is listed in Table I. The laser is a Q-switched Nd:YAG laser pumped by cw diode lasers. The output pulse energy is 100-250 μJ depending on the repetition rate.

It was discussed in our previous paper that the eye-safe criterion can be satisfied at 1.06 μm with a low pulse energy high repetition lidar if the laser output is expanded and is shut off immediately for more than 1 second when the strong return from an obstacle is detected in the lidar signal.[1] The idea is basically similar to that in the micro pulse lidar.[2] But, in our method, we consider a safety device to shut off the laser. With this method we do not need to consider the reduction factor for the maximum permissible exposure (MPE) for repetitive pulses. The maximum permissible pulse energy is approximately 200 μJ when the beam is expanded to 10 cm in diameter.

The return signal at 1.06 μm is collected with a 35 cm diameter telescope and detected with a photomultiplier tube. The detected signal is recorded with a computer controlled transient digitizer with a high speed averager. A block diagram of the system is shown in Fig. 1.

Table 1 Specfication of the lidar system

Laser	Diode laser pumped Q-switched Nd:YAG laser	
Wavelength		1.06 μm
Pulse repetition		max. 8 kHz
Pulse Energy		250 μJ at 1 kHz repetition
		100 μJ at 8 kHz repetition
Pulse Width		40 ns at 1 kHz repetition
		90 ns at 8 kHz repetition
Rec. Telescope	Cassegrainian	
Diameter		35 cm
Detector	Photomultiplier	
Quantum Effi.		0.0005
Data System	Transient Digitizer	
Sample rate		20 MHz
Accuracy		10 bits
Averaging Speed		500 Hz (present system)

EXPERIMENT

The performance of the low pulse energy lidar at 1.06 μm was tested with the system. The preliminary result is shown in Fig. 2. Fig. 2(a) shows the lidar return signal as a function of height. Fig 2(b) shows the range corrected return signal. The aerosol profile and a cloud at 1.5 km were detected.

The lidar return signals were averaged 4096 times with the averager, and the averaged profile was transferred to the computer. One hundred profiles were recorded with the computer. The profile shown in Fig. 2(a) and (b) is the average of the 100 profiles. The standard deviation of the profiles is also indicated in Fig. 2(a) and (b). Figure 2(c)

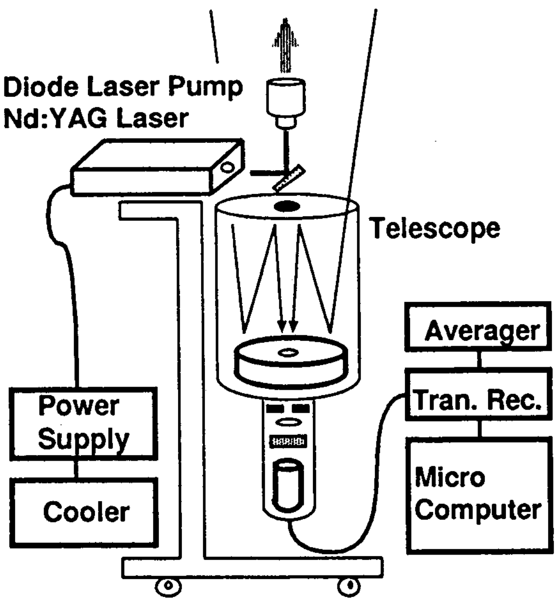

Fig. 1. Block diagram of the lidar system.

shows the signal-to-noise ratio (SNR) of the measurement.

In the present system the repetition of the measurement was limited at 500 Hz by the speed of the averager. Consequently, it took approximately 8 sec to accumulate 4096 signals in this experiment. When the data acquisition system will be improved to be operated at 8 kHz, it will take 1.25 sec to obtain the same SNR. In the actual observation we may average the return signal further for a few minutes, and the SNR can be improved approximately 10 times. We may conclude from the result that low pulse energy lidars will be useful for measuring the atmospheric boundary layer.

REFERENCES

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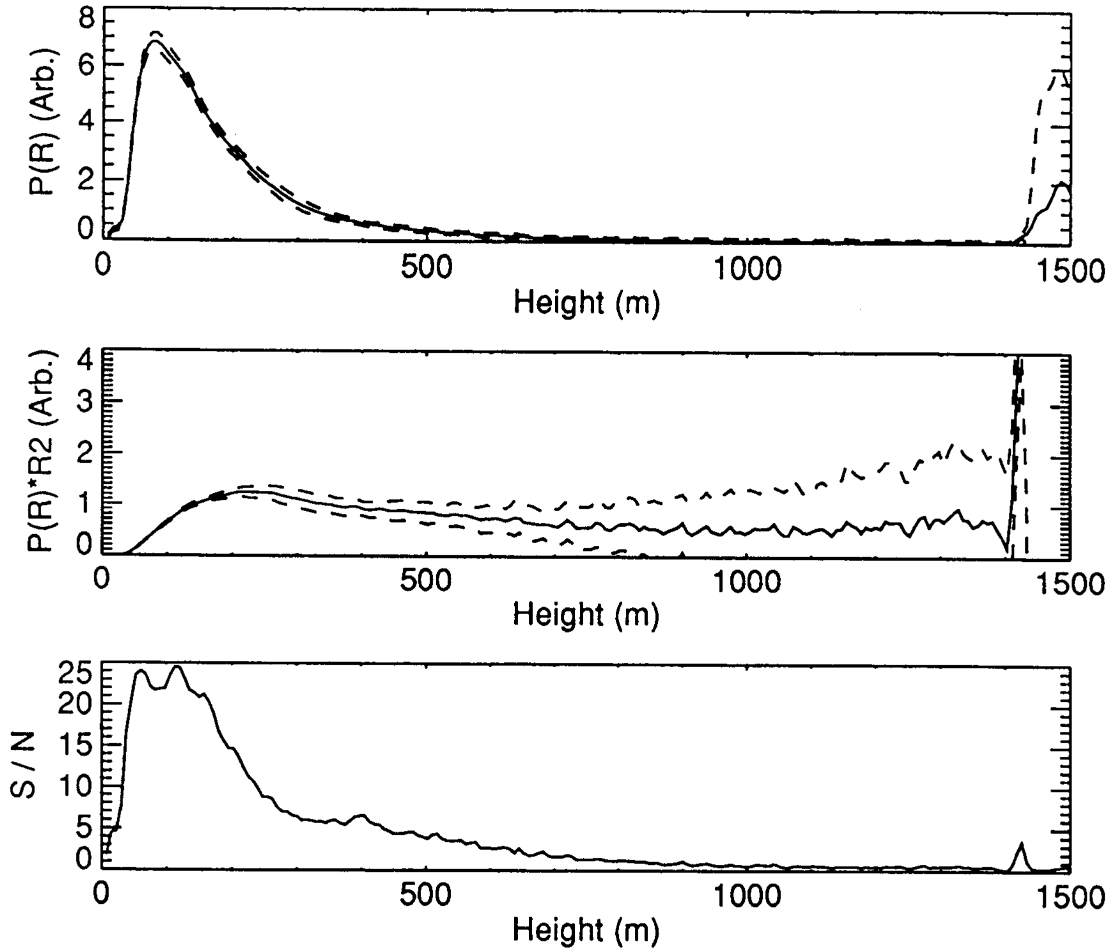

Fig.2 (a) Lidar signal as a function of height, (b) range corrected lidar signal, and (c) SNR.