C4 ライダーによるタクラマカン砂漠上空の風送ダスト観測 —日本および中国での試験観測—

Lidar Observation of Vertical Structure of Dust Layer over the Taklimakan Desert - Test Observations in Japan and China -

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Abstract:

A new lidar for measuring the aeolian dust from the atmospheric boundary layer to the stratosphere was developed in the Japan-China joint study on the mechanisms of aeolian dust outbreak from the Asian continent and its long-range transport (ADEC). The present paper describes an outline of the new lidar and some results of test observations at Tsukuba and Aksu, Xinjiang, China.

1. Introduction

Desertification is one of the serious environmental problems in the arid and semi-arid regions of the Asian Continent. Dust storms are regarded as one of the important manifestations of desertification. Kosa, the Asian Dust, is a signal of coming spring in Japan. In early spring, duststorms frequently occur in the arid regions in China. A few days later, Kosa phenomena are observed in Japan, especially, in Western Japan. In spring of East Asia, the effects of Kosa to the radiation transfer and cloud micro physics are significant.

Japan-China joint study on the mechanisms of aeolian dust outbreak from the Asian continent and its long-range transport has started since April 2000 in order to figure out the mechanism of the mineral dust outbreaks from arid regions into the atmosphere and to evaluate its annual variability, and is aimed to contribute for the understanding of the aeolian dust impact to the global climate system. As a part of this joint study, a lidar Observation of vertical structure of the dust layer over the Taklimakan Desert is planned at the Aksu Water-balance Station (AWS) of Xinjiang Institute of Ecology and Geography in April 2002.

The present paper describes the outline of the new lidar and some results of preliminary observation at Tsukuba, Japan.

2. Instrumentation

We have developed the new lidar system for this study. The lidar system is single wavelength Nd:YAG laser based system and designed to measure the vertical profiles of backscatter and the depolarization of the aerosol particles from near the ground and up to the stratospheric aerosol layer. The main purpose of this measurement is to clarify the mineral dust outbreaks in the desert so that we have to observe the quantitative dust profiles as wide altitude range as possible. In the atmospheric boundary layer, calibration of the lidar signal is usually very difficult since the aerosol free layer cannot be found any time. Even in the free troposphere, aerosol free layer does not exist stably. So, we designed that the system can measure the stratosphere where the aerosols are not so much as the troposphere and exist stably. Also, to clarify the diurnal variation of the aerosol profile, it is thought to be very important to measure continuously during day and night time.

The schematic diagram of the lidar system is shown in Fig. 1. A pulsed Nd:YAG laser is employed for the transmitter. The pulse energy of the laser is 300mJ at 532nm and the pulse repetition is 10Hz. Two telescopes, which diameter is 200mm and 355mm respectively, are used to expand the dynamic range of the receiving signal strength. The smaller and lager telescopes is used to measure the lower and upper atmosphere respectively. To measure the aerosol layer in the lowest altitude range, the smaller telescope and transmitting laser light are aligned coaxially. The larger telescope is set Parallel to the smaller telescope and the distance of the optical axes between the laser light and the telescope is 780mm. Two photomultiplier tubes are used for the detector of the smaller telescope and receive the parallel (P) and perpendicular (S) component to measure the depolarization ratio of S/P. Depolarization ratio is one of the important parameter of the lidar system to distinguish the unsphericity of the target particles. The received light by the lager telescope is separated to the parallel and perpendicular (S) component, and the parallel component is splitted to the two channels to expand the observable altitude range. The ratio of the signal strength of the two parallel channels (P and P') are 9:1, so that the dynamic range of the received signal is extend about 10 times. The electrical gate circuit is add to the higher altitude channel P to avoid from the strong signal from near the ground. The 8 bit analogue-to-digital converter is used for the data processing of the signals from the lower receiver and 12 bit A/D converter and the photon counting system is used for the upper receiver to expand the dynamic range of the signals. Using these 3 parallel and 2 perpendicular channels, and the both A/D conversion and photon counting systems, the system can measure the altitude range from near the ground, hopefully 150 m, up to the stratosphere (30km or above).

All optical component such as laser, laser beam expander, mirrors, telescopes and secondary optics is set on the optical bench to make a stable measurement. All instruments such as the optical components, data processing instruments and electronics are contained in the environment shelter. Two optical windows are set on the ceiling of the shelter to cover the field of view of the two telescope. Each optical window have two coated optical glasses to avoid dewing or frosting outside and the space between the grasses is purged by the dryed nitrogen gas to avoid dewing or frosting inside the glasses. To get the capability of the daytime measurement, very narrow band interference filters with high transmittance at the observing wavelength are used on the both receiving system. Using this configuration, we expect that we can measure the whole troposphere and stratospheric aerosol layer in night time and whole troposphere and lower stratosphere even in day time. Specifications of the system are shown in Table 1.

3. Concluding Remarks

The new lidar for measuring the aeolian dust from the atmospheric boundary layer to the stratosphere has been developed in the ADEC project. The test observations at MRI, Tsukuba and Aksu, Xinjiang, China were made. The analog channels can measure the scattering ratio from the atmospheric boundary layer to the lower stratosphere, using the dual receiving telescopes with diameter of 20 and 35 cm, and with dual sensitivity (10% and 90%) photomultiers. Photon counting channels with the electrical gating can measure a profile of the upper atmosphere up to the stratosphere.

At a next stage, we will try to estimate the aerosol optical thickness for the whole atmosphere over the Taklamakan Desert with using the lidar data and the sky radiometer.

Acknowledgements

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Tab.1 Specification of the Lidar System

Transmitter

Laser	Nd : YAG
Wavelength	532 nm (2nd harmonics)
Pulse Energy	300 mJ
Repetition	10 Hz
Beam Expander	5×
Beam Divergence	~ 0.2 mrad

Receiver

Range	Lower		Upper		
Telescope Diameter	200 mm		355 mm		
Geometry	Coaxial		Parallel		
Field of view	3 mrad		1 mrad		
Bandwidth	~ 0.5 nm				
Polarization	P	S	P (Upper)	P (Lower)	S
Transmittance	~ 50 %			~ 5 %	~ 50 %
Detector	PMT (Hamamatsu R3234-01)				
Gating	None		Electrically	None	

Data Processing

Num. of Channels	2 (4 max)	3
Bin Width	10 ns nominal, 5 ns min. (100 MS/s, 200 MS/s max)	50 ns (20 MS/s)
Bin Number	81920	16384
Band Width	25 MHz	10 MHz (A/D), 10～300MHz (Counting)
Data Processing	A/D (8 bit)	A/D (12 bit) and Photon Counting (250MHz)

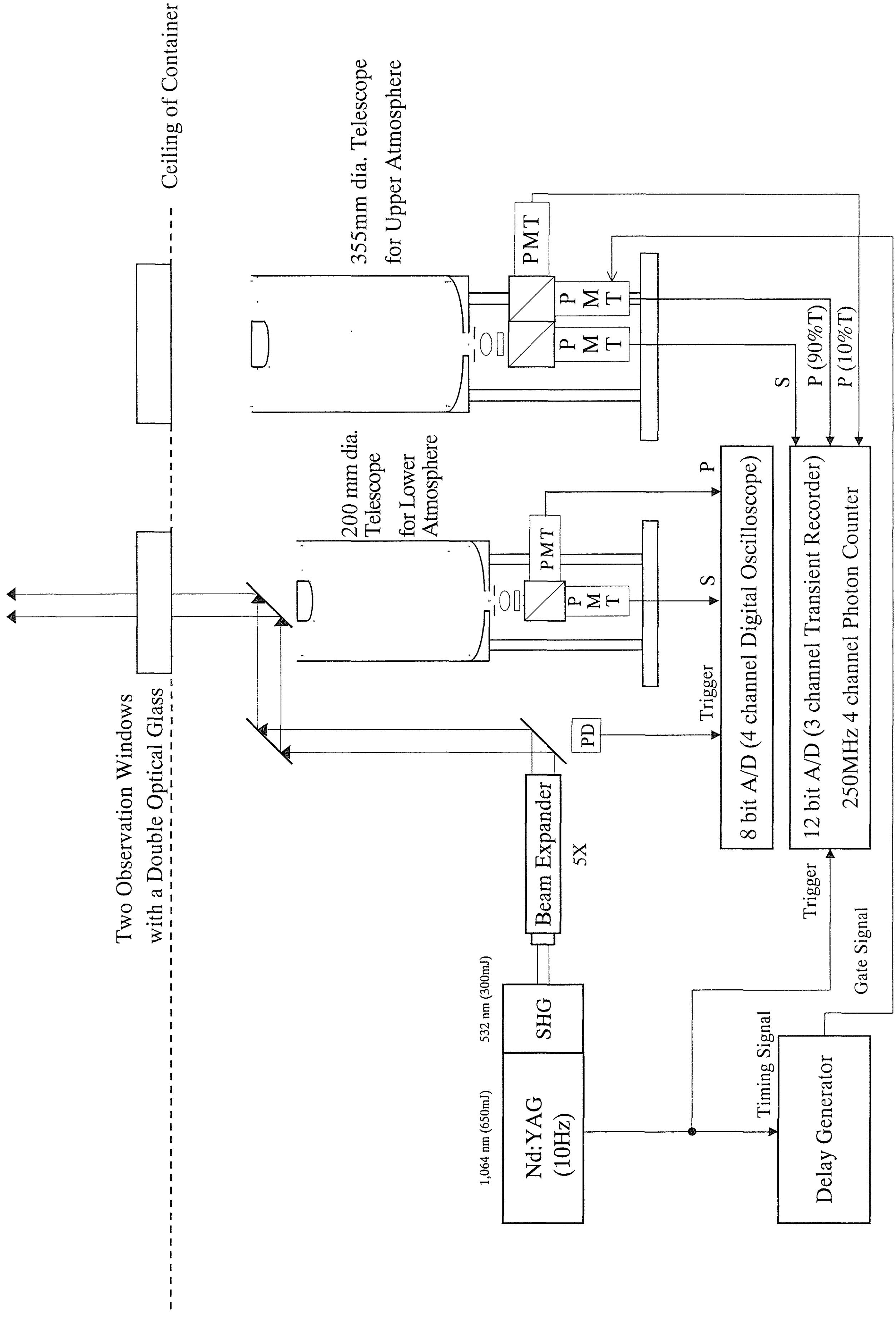

Fig.1 Block-diagram of the new desert lidar