POLARIZATION LIDAR FOR AEROSOL OBSERVATIONS IN THE TROPOSPHERE AND LOW STRATOSPHERE OVER SUWON (127°E, 37ºN), KOREA

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ABSTRACT

In this paper we describe a polarization lidar for aerosol observations in troposphere and low stratosphere. The lidar system description and first results of observation over Suwon, Korea (127°E, 37°N) are presented.

1. INTRODUCTION

The lidar techniques are now widely considered as being among the most powerful means used in the study of atmospheric objects and processes. Widespread use of lidar system is prompted by possibilities for remote detection of aerosol's optical properties with high vertical and temporal resolution. The mineral dust is one of major continental aerosols, which play great effects on radiation budget and climate. Because the mineral aerosols are composed by nonspherical particles, basic approach to detection of mineral aerosols is rest on measurements on polarization state of the lidar signal.

Over the past years, long time observations of mineral aerosols in the low and middle troposphere were performed in Suwon, Korea [1,2]. To study optical properties of mineral aerosols in high troposphere and low stratosphere a new polarization lidar system was developed. In this paper we describe the lidar system and first results of observations.

2. LIDAR SYSTEM

The polarization lidar system for observation of aerosol in the troposphere and low stratosphere is in operation since January 2006. Figure 1 show the block diagram of the lidar. The working wavelength is 532 nm. The lidar transmitter is a flash-lamp pumped, Q-switched, Nd:YAG laser model "Continuum Surelite II". Typical output energy at working wavelength (532 nm) is 250 mJ with pulse width 4-6 ns. During the observation was used 10 Hz laser pulses repetition rate. The beam divergence is 0.5 mrad.

The lidar receiver used a 60 cm main mirror diameter Cassegrain telescope. The equivalent focus length is 600 cm. The telescope is mounted vertically by tunable supports. The backscatter light collimated by the telescope is collimated with doubled lens. A pinhole determining FOV to be 0.3 mrad is used.

A polarization beamsplitter divides the received light in two components with polarization parallel and perpendicular respect to the polarization of transmitted light. Both channels are filtered by a narrow band pass interference filters to reject background light. The bandwidth of filters is smaller than 1.5 nm (FWHM). Couple mini photomultiplier tubes "Hamamtsu R7400U-20" are used as detectors.

As data acquisition system a transient recorder TR40-160 (Licel, GbR, Berlin) and a Linux based PC are used. The transient recorder combine a 12 bit at 40MHz Analog-to-Digital converter for analog detection with a 250MHz fast photon counting system. The maximum height resolution is 3.75 m. An Ethernet control module using a TPC/IP protocol allows remote control and data transfer for both analog and photon counting records.

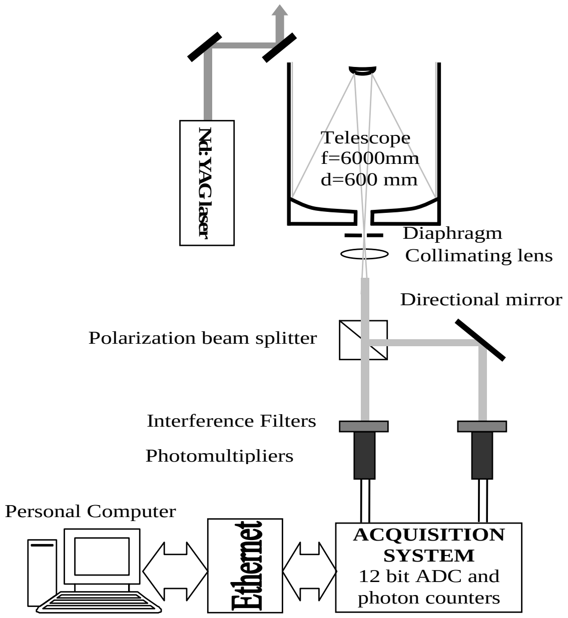

Fig.1 Block diagram of lidar system

By using combination of analog and photon counting detection the transient recorder is especially suited to recording of high dynamic range lidar signals. The lidar signals are detectable for altitudes form 500 m to 30 km. The lidar system has ability for both daytime and nighttime observations.

Figure 2 presents an example of lidar signal recorded simultaneously by ADC and photon counter. Profiles were received from 1000 to 1100 UTC (19:00 to 20:00 LST) on 18 January 2006. In the profiles an aerosol layer up to 1500 m and thin Ci-cloud about 8000 m can be seen. For this profiles is used an averaging by 40 bins, which corresponding of range resolution 150 m. The analog profile is scaled to equal of photon counting profile in altitude 5km by calibration constant.

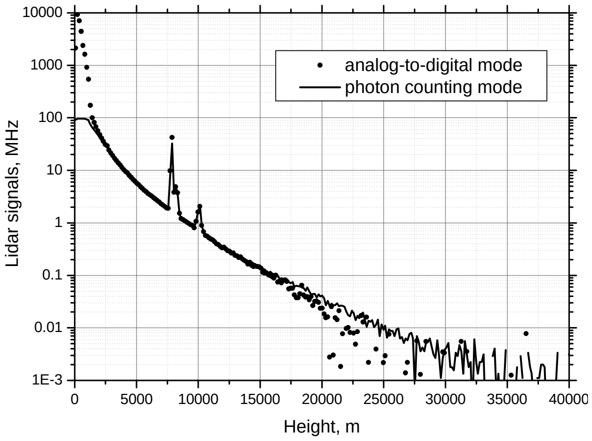

Fig.2. An example of lidar signal recorded simultaneously by analog-to-digital converter (circles) and a photon counter (line) obtained from 1000 to 1100 UTC on 18 January 2006 by "test" lidar; vertical resolution – 150 m.

In the figure one can see that by photon counting detection lidar signal is recorded up to 30 km, while analog-to-digital converting allows detection of the signal up 20 km.

For observations is used the combination of analog and photon counting records. The combination is performed based on a region where both signals are valid and have a high signal to noise ratio. In the present of Fig.2 this is range of counting rates from 0.5 MHz to 11 MHz, where ratio of the analog signal to the photon counting signal is a constant.

3. DEPOLARIZATION OBSERVATIONS

Figure 3 present an example of observation of polarization components of lidar signals. The combined analog and photon counter signal are presented. In the same figure profile of total depolarization ratio also is shown. The total depolarization ratio was defined as the ratio of the lidar signal with perpendicular polarization to that with parallel polarization, with respect to the polarization of the transmitted laser. Profiles are averaged by 3 000 lidar returns obtained from 1230 to 1235 UTC (21:30 to 21:35 LST) on 21 March 2006. The vertical range resolution is 60 m.

The parallel polarized lidar signal is detectable up to 25 km, while cross polarized signal is observed up to 17 km. The vertical profiles of the polarization components of lidar signal shows presence of two aerosol layers – first one up to 1.5 km altitude and second from 1.5 km to 3 km. In additional a Ci-cloud desk was detected in altitudes from 5 km to 7 km.

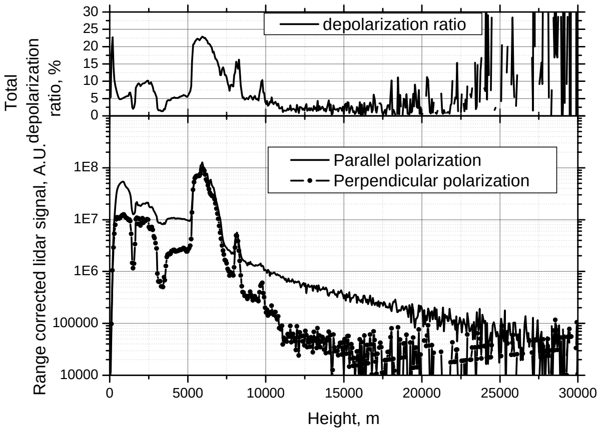

Fig.3. Lidar signals and depolarization profiles obtained from 1230 to 1235 UTC on 21 March 2006.

In the low aerosol layers depolarization ratio was about 5%, which corresponding of scattering from spherical particles. Significantly higher – about 10% are values of depolarization in the aerosol layer from 1.5 km to 3 km. These values indicate presence of mineral dust with nonspherical particle shape. The value of total depolarization ratio in the clouds is about 20%.

In the aerosol free region from 12 km to 17 km depolarization ratio varies about 2%, which values is close to the theoretical value of depolarization in case of scattering from air molecules 1.5%.

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