S3-4 Remote-Sensing of Atmosphere over Korean Peninsula by Upgraded Ozone DIAL and Multiwavelength Aerosol Lidar

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1. Introduction

The first lidar measurements in Korea performed successfully on September 1992 by ILE (Institute for Laser Engineering of Kyung Hee Univ.)[1]. After it, till October 1998 Combined ozone lidar, aerosol lidar, and pollution lidar are developed and operated [2].

In this year (on June), upgrade program of ozone lidar (308/351 nm) and Multi-wavelength aerosol lidar (355/532/1064/387/408 nm) are completed. With these lidars, stratospheric ozone from 10 km up 40 km, aerosol backscattering ratio, distribution function, particle size, depolarization ratio, extinction coefficients, water vapor, and temperature within 2 km up to 50 km can be measured respectively. It's vertical and slant-path measured data will be very helpful to understand the chemical and physical behavior in troposphere and stratosphere. All these measurements mentioned above will be doing continuously by ILE as a key station of GBONK network in Korea.

2. Upgraded Ozone Lidar

2-1 System

The Ozone lidar system uses two laser systems for DIAL measurements, one is XeCl laser which emit 308 nm with about 35 mJ and another is XeF laser, 351 nm with 30 mJ. Both laser has the beam divergence of 0.7 mrad and maximum repetition rate 40 Hz. The emitted pulses of 308 nm and 351 nm sound to atmosphere one by one with delay time of 10 msec. The photo diode is installed at end of transmitting system at top of case of telescope for transmitting of laser which is used as start signal of counting system.

The Back scattered signal received with 600 mm cassegrain telescope with field of view of 1.6 mrad. After telescope, mechanical chopper installed to blocking the high intensity signal in low altitude. Optical spectrometer with two 308 nm and 353 nm channels is installed behind the pin-hole. Each wavelength separated into Photon counting mode and analog mode by beam splitter then detected with PMT of Phillips XP2018B and Russian PMT of FEU 83 respectively. The spectral bandwidth of interference filter before PMT is about 5 nm. Total optical transmittance at each channel is about 10 – 20 %. The scheme is designed for the adaptable variation of altitude for dynamic range. The 200MHz Photon Counter and 30MHz 12bit Analog-Digital converter are used as photon signal counter.

2-2 Ozone Concentration measurements

Fig. 1 shows vertical ozone concentration profile from 10 km up to 35 km which we measured on July 02, 1999 in night time. It's first field experimental results after upgrade of ozone lidar. The repetition rate is 10 Hz and total number of shots is 10,000. All the signal is counted by Photon counter-mode. The peak of ozone concentration is 4.8 x 10^{12}(mol/cm^3) at about 24 km.

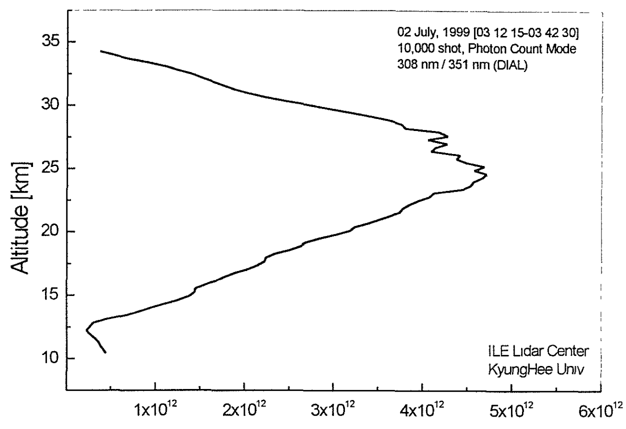

Fig. 1 Vertical Ozone Concentration Profile measured by 308/351 nm DIAL

3. Multi-Wavelength Lidar System

3-1 System

The Multi-wavelength lidar system consists of 3 wavelength transmitting system and 5 wavelength receiving system. Transmitting system generates 355 nm, 532 nm, 1064 nm simultaneously with 122 mJ, 128 mJ, 220mJ. The maximum repetition rate of the laser is 10 Hz, The laser system is Continum-Surelite Nd:YAG laser with 2nd, 3rd harmonic generator. The generated lasers are emitted to atmosphere after passing the beam expander. On the beam expander, the Glan prism is attached to determine the polarization angle of laser light.

Telescope is cassegrain type of 500 mm diameter with 15 angles min and 1685 mm focal length. Just behind the telescope the mechanical chopper are installed. The position of optical input is moveable according to the selection of measurements mode. By means of screw rotation the mobile optical plate is moved on guides toward stops, establishing optical system in mode of operations “Aerosol backscattering and Particle size estimation mode”, “polarization mode”, and “Raman measurements mode”. .Firstly, in mode of Aerosol backscattering and Particle size estimation mode, The 355nm, 532nm, 1064nm wavelength are separated by spectral splitters then detected by PMT. In mode of polarization, the light 532 nm wavelength fall on vollastone prism, then separated into ordinary beam(S) and extraordinary beam(P) then detected by PMT. Finally, in mode of Raman measurements, the light is guided through fiber and fall into Raman receiving box for Raman backscattering signal detection. Raman receiving box are consists of three separated channel for intensity measurements of 355nm, 386.7nm, 407.5nm. The fiber bundle which used for guide is fused sillica guide with 1 m length and 3mm diameter. The transmission in a wavelength range 355-410 nm is about 55%. All interference filters are made so that maximum wavelength is some more than wavelength of acceptance. This effect is used in the Raman analyzer for the exact adjustments. After detection by PMT model 136 and 83, the signal counted by Photon Counter or Analog-Digital Converter. These two mode are designed to achieved higher resolution in low altitude below 10 km.

3-1 Aerosol Backscattering Ratio, Surface area concentration, Depolarization

During field-testment of Multi-wavelength lidar, we have been measured small scale of Asian dust in altitude range of 6 to 12 km. Fig.2 show the measured Aerosol Backscattering ratio of 353 nm and 532 nm. Fig. 2. (a) shows the Asian dust profiles measured on May 20 and (b) general aerosol backscattering Ratio measured on July 2 in this year. In case of (a) the three peak of ratio at 532 nm are 2.43 (8 km), 1.85 (9 km) and 1.96 (11km) are measured. But In case of (B) the maximum peak of it are about 1.3 at 5, 6.2 and 9 km.

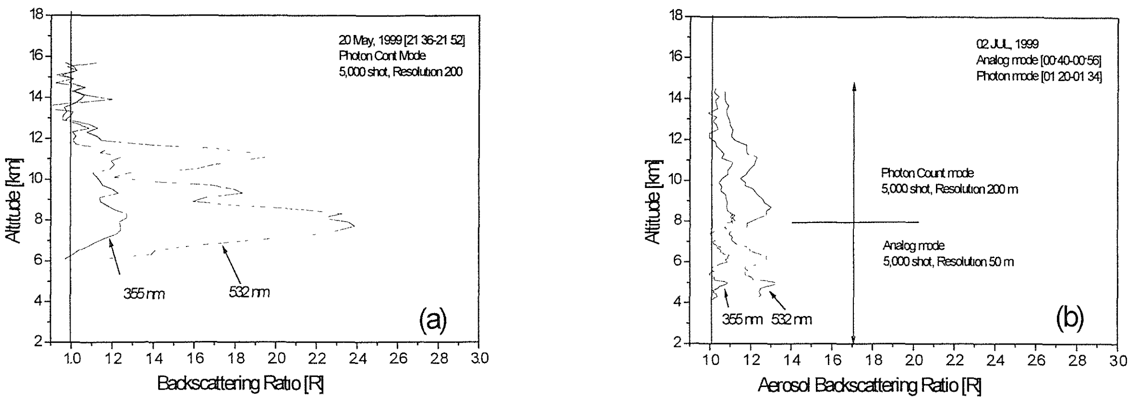

Figure 2. Vertical Profile of Aerosol Backscattering Ratio

So, with this signal, we calculated Surface Area concentration of aerosol versus Particle radius as the Fig 3. In Figures, (a) show the concentration in layer of 6-9 km, 9-10km and 10-12 km measured on May 20 and (b) in layers of 6-7 km, 7-10 km and 10-12 km. When we compared the data of (a) with (b), In case of (a), the large size particle more than 0.4 μm located in 6-10 km layer , but in case of (b) the large particle is not shown.

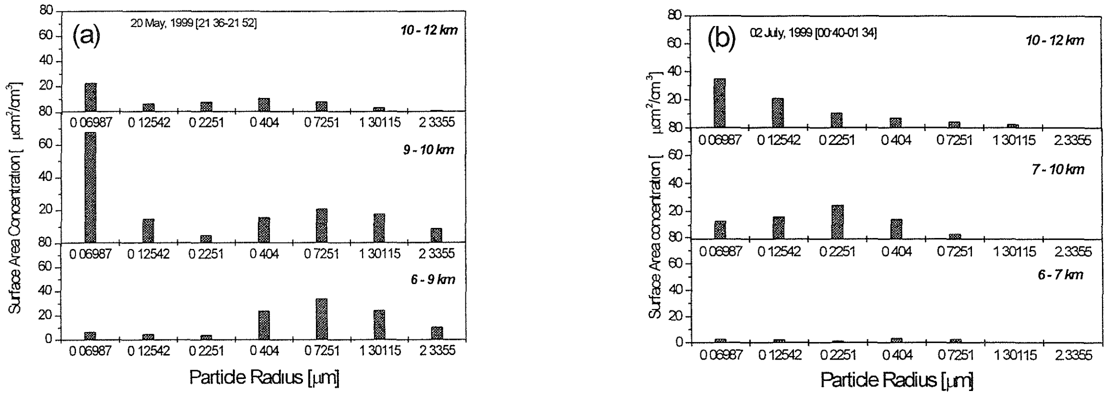

Figure 3. Surface Area Concentration of Aerosol versus Particle Radius in several layers.

Fig. 4. Show the depolarization ratio is derived from the signal of 532nm (S) and 532 (P). This measurements doing on July 2, 1999. Below the 12 km the value is in range of +1.6 to – 0.8 and fluctuated. But above 12 km, it ratio is almost constant of 1. With this result, we can estimate that the tropospheric aerosol is non-homogeneous.

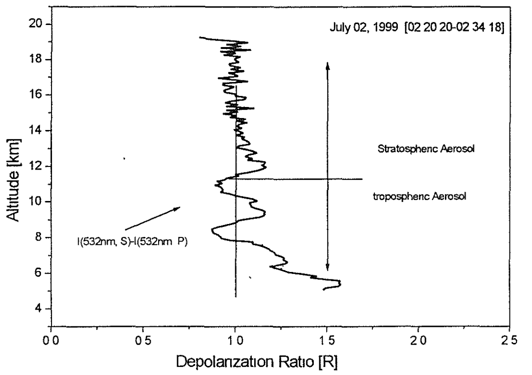

Figure 4. Vertical Profile of Depolarization Ratio

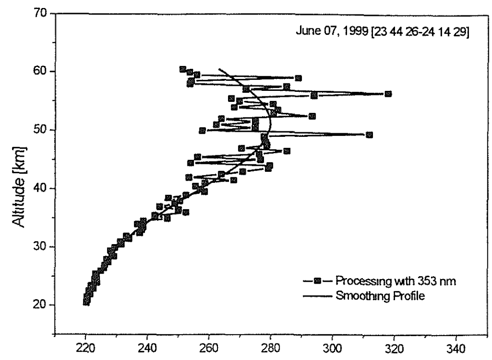

Figure 5. Vertical Profile of Temperature

3-2 Temperature

Fig. 5. Shows the temperature profile is derived from 353 nm signal measured on June 7. During this experiment, the signal of 353 nm transmitted upto 60 km with 10,000 laser shot. We assume that the stratospheric aerosol is not located above 20 km, then calculated temperature from molecule backscattering signal of 353 nm. In the figure, the line is the results after smoothing and Gaussian fitting of raw temperature profile. The temperature is 220 K at 20 km. Then slightly increased up to 280 K at 50 km. After 50 km, it decreased.

3-3 N_2 and Water Vapor

Fig. 6. Shows the slant-path return signal of 353 nm, 387 nm(N_2 Raman) and 408 nm (Water Vapor Raman) measured on June 14. Now the data-processing program to calculate the concentration of N_2 and Water Vapor are on developing. With this field-testment result, we hope that N_2 and Water Vapor concentration can be measured till 8 km and 5 km respectively.

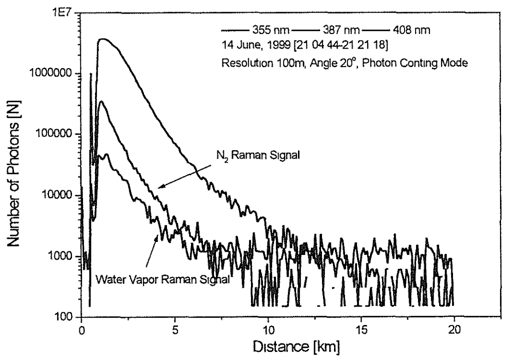

Figure 6. Slant-path measurement profile of 353 nm, 387 nm and 408 nm

Reference

1. C.B.Park, C.H.Lee, S.S.Khmelevsov, "Measurement of tropospheric and stratospheric ozone using combined UV-DIAL system", Conference of CLEO'94, CWD6, p. 198 (Anaheim, USA,1994. 5)

2. C.B.Park, K.H.Park, and C.H.Lee, "Lidar Observation of Ozone and Aerosol in the Stratosphere and Trosphere over Suwon, Korea", Advanced in Atmospheric Remote Sensing with Lidar, A.Ansman *et al* ed., pp. 545-548, Springer Berlin (1997. 1)