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DIAL MEASUREMENTS OF WATER VAPOR USING TWO NARROWBAND Ti:SAPPHIRE LASERS

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INTRODUCTION

Measurements of water vapor profiles are very important in studies of the atmospheric dynamics, aerosol growth effects, and the earth's radiation effects. This paper describes DIAL techniques for water vapor measurements in the atmosphere using two narrowband Ti:sapphire lasers. Goal of this investigation is an airborne lidar. As a laser suitable for this purpose, we selected the Ti:sapphire laser.

The water vapor profiles measured with this ground based DIAL are compared with those measured simultaneously at the same lidar site of Tokyo Metropolitan University by a Raman lidar.

SYSTEM AND MEASUREMENTS

Our water vapor DIAL system consists of two narrowband (<500MHz) Ti:sapphire lasers (HRL-1c) pumped by a frequency doubled Nd:YAG laser, a high resolution wavemeter (1pm), two photoacoustic (PA) cells, a Celestron telescope with a 20cm diameter primary mirror, and a data acquisition system with two inputs.

Table 1 Specifications of the DIAL system.

Pump laser (Nd:YAG SHG)		
	wavelength	532nm
	energy	300mJ/pulse
	repetition rate	10Hz
Ti:sapphire laser		
	wavelength range	700-900nm
	energy	1mJ/pulse
	bandwidth	500MHz
	resolution	0.25pm
Receiver		
	diameter	200mm
	method	photoncounting
	range resolution	100m
	field of view	3mrad
Wavelength		
	on line	13872.68cm^{-1} (720.643nm)
	off line	13871.60cm^{-1} (720.699nm)

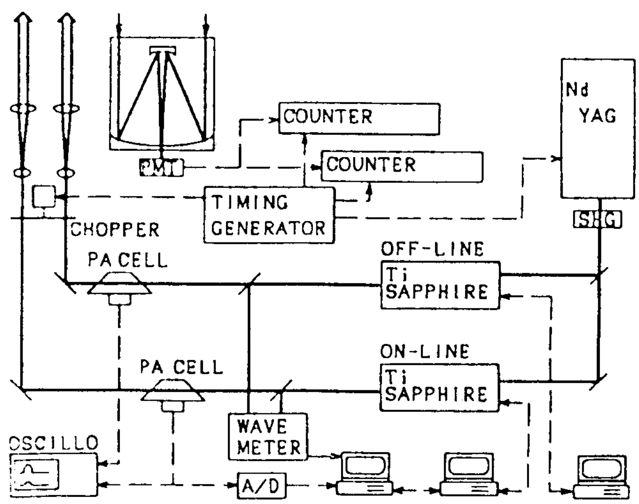

Fig.1 Schematic diagram of the DIAL system.

The PA cell is designed by ourselves. Using the PA cell, the wavelength is decided within 0.1pm accuracy. The wavelength stability of the Ti:sapphire laser is about 0.25pm. Their specifications are shown in Table 1 and the schematic diagram of the DIAL system is shown in Figure 1.

Firstly, one Ti:sapphire laser is tuned to the water vapor absorption line of near IR region (ex. 721nm) using a computer-controlled grating in the laser cavity monitoring the high resolution wavemeter and the PA cell. To keep the tuning to the absorption line of water vapor during a series of observation, the monitored signal of the PA cell is fed back to the computer to control the grating. Secondarily, another Ti:sapphire laser is tuned to the very weak absorption region near the absorption line of water vapor in the same way as mentioned above. The data acquisition system consists of a home-made photon counter/interface unit with dual inputs and two microcomputers. The photoncount sampling gate is 667ns corresponding to a 100m range resolution.

The repetition rate of the Nd:YAG laser is 10pps. The output power of the frequency doubled Nd:YAG laser is divided into two parts and is used for pumping the two Ti:sapphire lasers. The two laser beams of the lidar are transmitted alternately into the atmosphere using a chopper synchronized with the Nd:YAG laser shot. Therefore, the actual accumulating rate of each photoncounter is 5pps. The error caused from this quasi-simultaneous measurement depends on the aerosol advection speed and inhomogeneity of aerosols.

The water vapor profiles measured simultaneously with the DIAL and the Raman lidar excited with wavelength of 532nm at Tokyo Metropolitan University are shown in Figure 2. Both profiles are in agreement within their errors below 4km altitude.

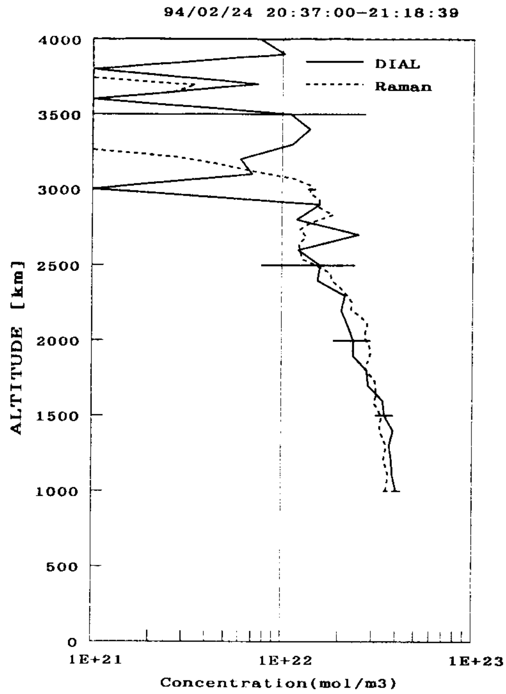

Fig.2 The water vapor profiles measured simultaneously with the DIAL and the Raman lidar excited with wavelength of the 532nm at Tokyo Metropolitan University

CONCLUSION

Errors due to uncertainties in the knowledge of the absorption cross section are caused by atmospheric effects and laser system characteristics. It is known that the main atmospheric effects are temperature sensitivities, pressure broadening and pressure shifts of water vapor absorption lines, and Doppler broadening of the Rayleigh backscattered component of the lidar return [Ismail and Browell (1989)].

The stability of the laser and the tuning error of our DIAL system are specified to be less than 0.25pm. Owing to computer simulation of water vapor DIAL performance, if the laser has appreciate power, it is possible to measure within 10% density accuracy of water vapor at 10km altitude.

Our computer controlled laser system and tuning monitoring system using the PA cell could decrease the errors remarkably.

We think that our DIAL system should be improved on several points for the airborne lidar. They include developments of techniques concerning (1) the LD pumped Nd:YAG laser, (2) double pulses, (3) dual wavelengths and (4) injection seeding by a single mode diode laser.

REFERENCE

S.Ismail and E.V.Browell (1989), Appl. Optics, **28**, 3603-3614.