MEASUREMENT OF LOWER-ATMOSPHERIC CO2 CONCENTRATION DISTRIBUTION USING A COMPACT 1.6 μm DIAL

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ABSTRACT

Knowledge of present carbon sources and sinks including their spatial distribution and their variation in time is one of the essential information for predicting future CO2 atmospheric concentration levels. The differential absorption lidar (DIAL) is expected to measure atmospheric CO2 profiles in the atmospheric boundary layer and lower troposphere from a ground platform.

We have succeeded to develop a compact 1.6 μm DIAL system for measuring CO2 concentration profiles in the lower atmosphere. This 1.6 μm DIAL system consists of the optical parametric generator (OPG) transmitter that excited by the LD pumped Nd:YAG laser with high repetition rate and the receiving optics that included the near-infrared photomultiplier tube operating at the analog mode and a 25 cm telescope. CO2 concentration profiles were obtained up to 2.5 km altitude.

1. INTRODUCTION

For the detailed analysis of forest carbon dynamics and CO2 fluxes of urban area, the CO2 concentration measurement techniques with high spatial and temporal resolution are required in the lower atmosphere [1]. We have developed a direct detection 1.6 μm DIAL technique to perform range-resolved measurements of vertical CO2 concentration profiles in the atmosphere. This 1.6 μm DIAL system has a 60 cm telescope for vertical measurement and a 25 cm scanning telescope for horizontal measurement. The vertical distribution of CO2 concentration from 2 km to 7 km altitude has been observed using two telescopes with different apertures [2,3].

In order to observe CO2 distribution in the tropopause, we have developed a compact light source and have improved the receiving system. This new CO2-DIAL system can observe the vertical CO2 concentration profile from 0.4 km to 2.5 km altitude.

2. COMPACT CO2-DIAL SYSTEM

In order to observe the CO2 concentration distribution in the lower altitude, the output power of transmitter and the dynamic range of the receiver of the CO2 DIAL have improved. This 1.6 μm DIAL system consists of the OPG transmitter that excited by the LD pumped Nd:YAG MOPA (Master Oscillator Power Amplifier) system [4] and a 25 cm coaxial telescope. Fig.1 shows a schematic of the 1.6 μm OPG transmitter. The MOPA system consists of an oscillator (IB laser, DiNY pQ10, 9.2 mJ, 400Hz), and a preamplifier (Cutting Edge Optronics, REA5006-3P5). A pulse energy of 23.3 mJ (1064 nm) and that of 2.1 mJ (1572 nm) are obtained at the repetition rate of 400 Hz.

Fig. 2 shows a schematic of the compact 1.6 μm CO2-DIAL system. Since the change of signal intensity is larger near the ground, we select the analog mode and use two-channel PMTs to expand the dynamic range. One is the channel for close range and another is the channel for up to the upper boundary layer. This 1.6 μm DIAL system is available to measure CO2 concentration

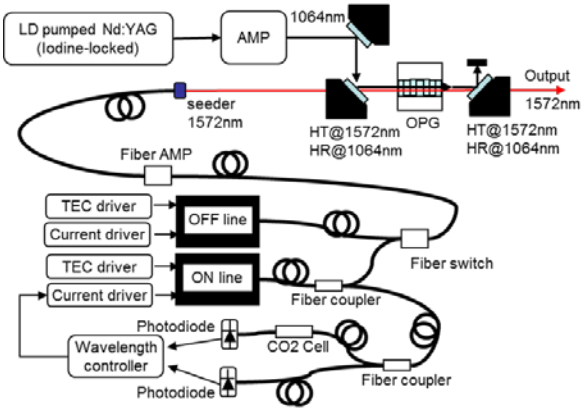

Fig. 1 Schematic of the 1.6 μm OPG transmitter.

profiles for daytime by using narrow-band interference filters (FWHM 1.0 nm). As the transmitter beam of this DIAL system is able to scan from -4 degree to 52 degree with elevation angle, the vertical distribution of lower CO2 concentration as well as the horizontal distribution from short range can be measured with high precision.

3. CO2 VERTICAL PLIFILES

The compact DIAL was achieved successfully measurements of CO2 concentration profiles for the range from 0.25 to 3 km with integration time of 30 minutes and range resolution of 300 m. Fig. 3 shows CO2 concentration profiles during a daytime segment of the measurement period. CO2 concentration increase in the lower altitude was observed at 12:00LT ~. Fig. 4 shows CO2 concentration profiles during a nighttime segment of the measurement period. CO2 concentration increase in the lower altitude was observed at 19:00LT ~.

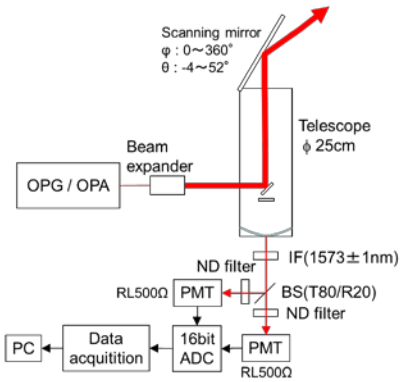

Fig. 2 Schematic of the compact 1.6 μm CO2-DIAL system.

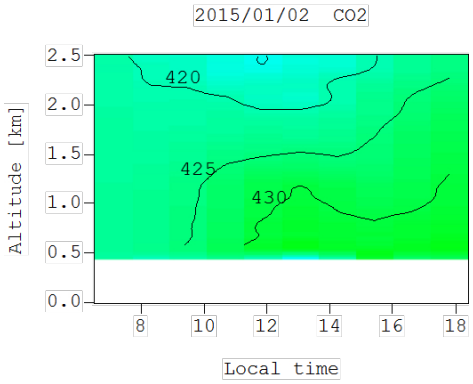

Fig.3 CO2 concentration profiles during a daytime. The contour interval is 5 ppm.

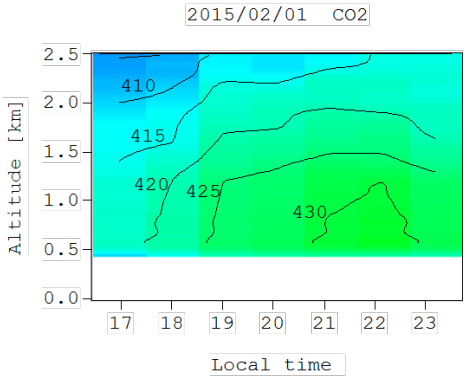

Fig. 4 CO2 concentration profiles during a nighttime. The contour interval is 5 ppm.

4. CONCLUSION

We have developed the compact 1.6 μm CO2-DIAL system for measuring in the lower atmosphere. The system operating at 1.6 μm wavelength that includes a 2 mJ QPM-OPG transmitter obtained temporal transition of vertical CO2 concentration profiles with suitable SNR in the atmospheric boundary layer during daytime and nighttime.

ACKNOWLEDGEMENT

This work was financially supported by the System Development Program for Advanced Measurement and Analysis of the Japan Science and Technology Agency.

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