25 mm　178 mm

Paper

3 行あける

16 ポイントまたは 24 級

# Analysis of $SO_2$ measurement accuracy by multiwavelength DIAL

←左右中央に書く

1 行あける

12 ポイントまたは 18 級

Taro Denshi* Member

Hanako Denki** Non-member

9 ポイントまたは 13 級

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This paper presents two multiwavelength methods to improve the accuracy of a DIAL system for measuring $SO_2$ in the lower atmosphere : a dual-DIAL method using three or four wavelengths, and a curvefitting method using five wavelengths. By the selection of appropriate wavelengths, these methods can eliminate the effects of ozone and aerosols. Since there is no significant difference in accuracy between the four wavelength dual-DIAL and curvefit methods, the former is advantageous for $SO_2$ detection in view of the measurement and data processing speeds.

左右 2 字分あける

248 mm

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8 ポイントまたは 12 級

**Key words**: laser radar, $SO_2$, DIAL, multiwavelength differential absorption

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2 行分　1 字さげる※　10 ポイントまたは 14 級

## □1. Introduction

1 字さげる

□LIDAR (LIght Detection And Ranging) has been used for measurement of atmospheric pollutants by Raman scattering, resonant fluorescence, and differential absorption(1). Fig. 1 is a schematic diagram of a LIDAR system. This apparatus transmits laser radiation into the atmosphere, collects light backscattered by atmospheric molecules and particulates using a receiving telescope, and converts it to an electric signal using a photodetector such as a photomultiplier tube. The measurement height is obtained from the time delay between illumination and detection. Therefore, to measure the height profile one measures the received photon counts as a function of time delay relative to illumination using a multichannel scaler. The measurement range resolution $\Delta R$ is determined by the time width of the channel $\Delta t = 2\Delta R/c$, where $c$ is the speed of light. The smaller the time $\Delta t$, the better the range resolution, but the photon count per channel becomes less and the relative error larger.

本文は 9 ポイントまたは 13 級

This paper examines DIAL (DIfferential Absorption Lidar), a method to obtain the concentration profile of the measurement target molecule from the backscatter intensity at two or more illumination wavelengths. The measurement target is atmospheric $SO_2$, which is a substance causing acid rain. Until now, measurements of atmospheric $SO_2$ have been limited mainly to cases of localized $SO_2$ concentrations, e. g. smokestack exhaust and volcanic eruptions(2)~(4). In these cases, the $SO_2$ concentration is over 100 ppb, therefore the measurement was relatively easy and the measurement accuracy was not a problem. However, when measuring $SO_2$ in the ambient atmosphere, its concentration is of ppb order, and the measurement accuracy becomes an issue.

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8 ポイントまたは 12 級

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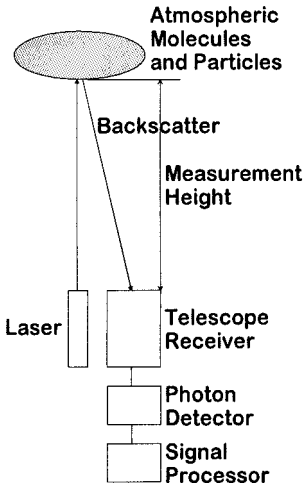


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図の説明は左右 2 字分あける。22 字以内は中央に書く

□□ Fig. 1. Schematic diagram of a LIDAR system □□

1 行あける

We performed a theoretical analysis of the measurement accuracy of conventional two-wavelength DIAL, and indicated the necessity of elimminating effects due to ozone and other substances which cause measurement error(5). In this paper, we examined the measurement accuracy of dual-DIAL methods using three or four wavelengths (consisting of a combination of two two-wavelength DIAL pairs) and a curvefit method using five wavelengths.

## □2. Multiwavelength Differential Absorption

2 字あける

### □2.1 Fundamentals of DIAL

□□The received energy for a LIDAR is given by the following LIDAR equation :

〔式の始まりは 2 字分さげる〕

$$□□E_r(R,\lambda_i)=[E_0\eta A]\frac{\Delta R}{R^2}\beta_\pi(R)\times \exp\left[-2\int_0^R(\alpha_0+\alpha_x)dR'\right] \quad \cdots\cdots(1)$$



24 mm

注：「1 字あるいは 2 字さげる」は，日本語文字の 1 字分あるいは 2 字分相当として下さい。

Here $E_r(R, \lambda_i)$ is the backscattered photon energy received from range between $R$ and $R+\Delta R$ from the illumination laser, $\lambda_i$ the illumination wavelength, $E_0$ the illumination energy, $\eta$ the optical efficiency of the

## 4. Conclusion

In this paper, we calculated the error due to ozone and aerosols in measurement of $SO_2$ concentrations of ppb order using DIAL. The statistical error of the return signal and background noise can be overcome by improving the system constant (laser output, receiver area, optical efficiency of the receiver). On the other hand, systematic errors due to ozone and erosols are inherent in the measurement method, and cannot be eliminated solely by improving the system constant. In conentional two-wavelength DIAL, the systematic error is over 1.5 ppb and the measurement accuracy is insufficient. In order to improve the measurement accuracy, a multiwavelength differential absorption method using three or more wavelengths is effective. In this paper we have considered dual-DIAL methods using three or four wavelengths and a curvefit method using five wavelengths, and indicated that the measurement errors due to ozone and aerosols can be reduced relative to conventional DIAL or eliminated. When these methods are compared, four-wavelength dual-DIAL is superior in view of measurement accuracy and measurement/processing speeds.

(Manuscript received September 25, 1997)

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ゴシック ↕ 1行あける


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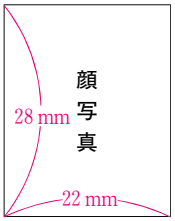



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