

Extended Summary の作成見本

Analysis of SO<sub>2</sub> measurement accuracy by multiwavelength DIAL

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The measurement accuracy of SO<sub>2</sub> in the ambient atmosphere by DIAL (Differential Absorption Lidar) is examined. Localized, relatively high (~100 ppb) SO<sub>2</sub> concentrations, such as smokestack exhaust, have been successfully measured by DIAL in the past. However, measurement of SO<sub>2</sub> in the ambient atmosphere (few ppb) is difficult because of effects due to ozone and other substances which cause measurement error. In this paper, we examine multiwavelength DIAL methods to improve the resolution of SO<sub>2</sub> measurement.

The absorption cross section of SO<sub>2</sub> near 300 nm is shown on Fig.1. Conventional DIAL uses the wavelength pair ( $\lambda_{on}=300.0$  nm,  $\lambda_{off}=299.3$  nm) for which the differential absorption cross section is  $\Delta\sigma \simeq 10^{-22}$  m<sup>2</sup>. This is about 30 times the value for ozone.

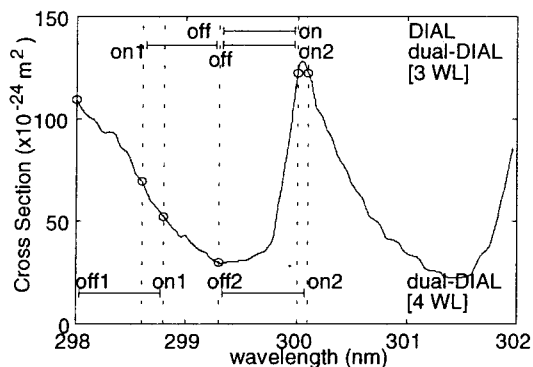


Fig. 1. Absorption cross section of SO<sub>2</sub> indicating wavelengths used in DIAL and dual-DIAL

The SO<sub>2</sub> measurement error due to aerosols and ozone for conventional two wavelength DIAL is about 1.5 ppb and the accuracy may be insufficient for measurement of SO<sub>2</sub> in the ambient atmosphere.

In order to remove these effects, we consider dual-DIAL methods using three or four wavelengths and a curvefit method using five wavelengths. The dual-DIAL methods consist of a combination of two DIAL wavelength pairs, ( $\lambda_{on}=300.0$  nm,  $\lambda_{off}=299.3$  nm) and ( $\lambda_{on}=298.6$ ,  $\lambda_{off}=299.3$  nm) for three wavelengths and ( $\lambda_{on}=300.1$ ,  $\lambda_{off}=299.3$  nm) and ( $\lambda_{on}=298.0$ ,  $\lambda_{off}=298.8$  nm) for four wavelengths. The curvefit method uses the wavelengths (299.70 nm, 299.90 nm,

300.10 nm, 300.55 nm, and 301.10 nm), which corresponds to a wavelength interval containing one absorption peak.

We calculated the SO<sub>2</sub> measurement error due to ozone and aerosols for the multiwavelength DIAL methods. A certain SO<sub>2</sub> concentration was assumed, and the backscatter signal (photon counts) was calculated using the lidar equation. The calculated SO<sub>2</sub> concentration was deduced from the signal, and its deviation from the initially assumed value was taken as the measurement error. The calculations were performed for vertical range upto 3 km, vertical range resolution 100 m, and the atmospheric visibility and ozone concentration as variable parameters. A background radiation of  $S_\lambda = 10^{-6}$  W/cm<sup>2</sup>-sr- $\mu$ m at  $\lambda = 300$  nm was included. The ozone concentration was taken to be uniform with respect to height and invariant within the measurement time. The atmospheric visibility and background radiation level were taken to be invariant within the measurement time. Fig.2 shows the SO<sub>2</sub> measurement error due to ozone for a typical atmospheric visibility of 10 km, and shows that the multiwavelength methods are effective in suppressing the effects due to ozone.

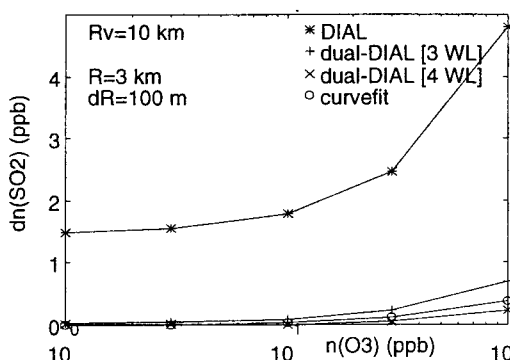


Fig. 2. SO<sub>2</sub> measurement error due to ozone

The effects due to aerosols can be similarly suppressed by the use of multiwavelength methods.

When the multiwavelength methods are compared, dual-DIAL using four wavelengths is best in view of measurement accuracy and speed.