CASE STUDY OF URBAN AIR POLLUTION OVER TSUKUBA AS OBSERVED BY UV OZONE DIAL

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ABSTRACT

Very large enhancements of ozone in the boundary layer are analyzed using UV ozone DIAL data over Tsukuba in the summer. Three ozone enhancement events were identified in the summer 2005. These events shared certain characteristics such that it took 3-4 hours to gain maximum ozone density of $2\text{-}3\times10^{18}/m^3$ after the beginning of sunshine. These characteristics imply that the enhancements are originated from urban air pollution in the Tokyo metropolitan area.

1. INTRODUCTION

Tsukuba (or Tateno), one of three ozonesonde observation sites in Japan, is located at 36.1N, 140.1E, about 50 km northeast of Tokyo [1]. At this site, very large enhancements of ozone are sometimes observed in the boundary layer in the summer. Their origin is thought to be anthropogenic air pollution emitted in the Kanto Plain [2]. We can see the snapshot nature of ozone vertical profile through ozonesonde observation or the temporal variation of surface ozone distribution with respect to individual pollution events. However, the temporal variation of ozone vertical profile around Tokyo metropolitan area is not known well.

In order to clarify characteristics of the enhancements of ozone in the boundary layer over the Kanto Plain we conducted some observations for 12 days from July to September 2005 using the UV ozone DIAL developed at the Meteorological Research Institute. Some observed results and discussion are presented in the following.

2. METHODOLOGY

Ozone profiles were observed using a three wavelength UV ozone DIAL which utilizes an Nd:YAG laser (FHG: 266 nm) and a single path Raman cell filled with carbon dioxide [3]. Three wavelengths produced are 276 nm, 287 nm, and 299 nm as the first to third Stokes lines of the stimulated Raman scattering. This DIAL can measure ozone density in the entire troposphere up to about 10 km within 30 minutes. The vertical resolution is about 100 m and the precision is less than 10% in the troposphere.

Additionally, data from the Atmospheric Environmental Regional Observation System managed by the Japanese Ministry of Environment and operational rawin sonde data at Tsukuba (Tateno) are used in this study.

3. RESULTS AND DISCUSSION

Among observed data for 12 days, very large enhancements of ozone in the boundary layer were detected in three days, namely on July 28, August 20, and September 8. Fig. 1 presents an example of the time-height cross-section of ozone density obtained on August 20. The lowest 300 m data is not obtained correctly, presumably due to saturation of photo multiplier tubes or misalignment, although the lowest observable height is estimated to be 200 m.

Fig. 2 depicts the sounding data obtained at 0900JST (UTC+0900) on the same day [4]. There exists the stable layer below about 1.5 km where the weak wind from the southwest blows. This implies that Tsukuba would be covered with air mass through the Tokyo metropolitan area. Fig. 3 illustrates the distribution of oxidant mixing ratio around the Kanto Plain at 1300JST obtained from the Atmospheric Environmental Regional Observation System [5]. Tsukuba was in thick oxidant area with more than 60 ppbv spreading to the north of Tokyo.

The features common to the three days are as follows.

1. The ozone enhancements appeared in the stable boundary layer in the daytime.
2. The ozone density increased to $2\text{-}3\times10^{18}/m^3$ (40-80

ppbv), large enough compared to the typical stratospheric ozone peak of about $6x10^{18}/m^3$.

3. It took about 3-4 hours to gain maximum ozone density.

4. The weather was clear. Temperature in the daytime was more than 30 degree Celsius. Additionally, weak wind from between the south and the west.

5. The ozone density decreased to low level in the nighttime.

6. The ozone density was low except the time when a pollution event occurred. The ozone density in the free troposphere is known to be low in summer because the Japan Islands are covered with clean air from the Pacific high. When a pollution event did not occur, the ozone density tended to be low even in the boundary layer.

The features described above indicate that the ozone enhancement events would be anthropogenic origin, spatially localized in narrow region, and have relatively short time scale.

In other season we were not able to find the features above. For example, during April and May neither ozone enhancements in the daytime nor significant temporal variations are observed though continuous high ozone density of about $2x10^{18}/m^3$ is sometimes observed for several days, which may be related to the phenomena with larger scale. From October to February high ozone density of more than $2x10^{18}/m^3$ is not observed in the boundary layer.

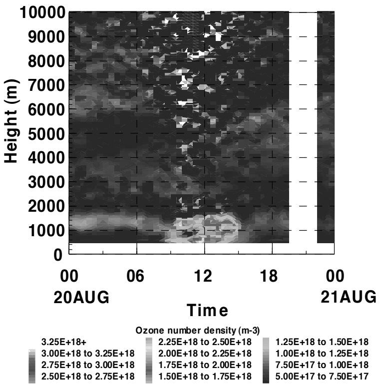

Fig. 1. Time-height cross-section of ozone density over Tsukuba on August 20, 2005 observed with UV DIAL.

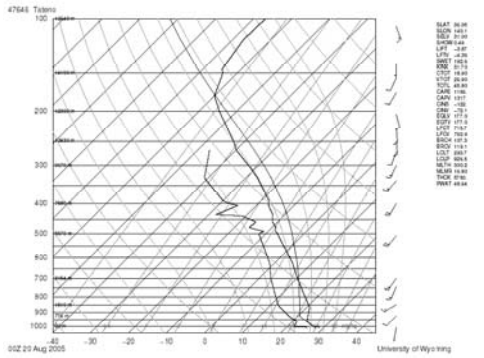

Fig. 2. Skew T, -log p diagram over Tsukuba at 0900JST on August 20, 2005 [4].

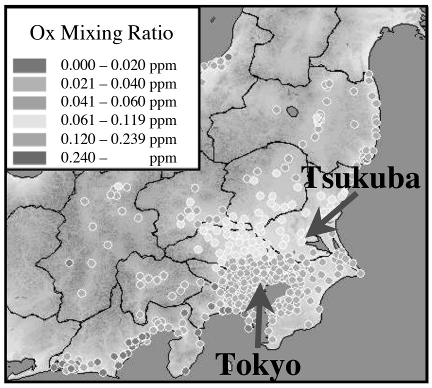

Fig. 3. Distribution of oxidant mixing ratio around the Kanto Plain at 1300JST on August 20, 2005 [5].

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