The origin and seasonal characteristics of tropospheric ozone observed over Pohang, Korea

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In this study, we present the analysis of vertical ozone sounding data observed over Pohang, Korea, and investigate to understand the governing mechanisms for seasonal ozone maximum in June. The vertical ozone profiles in June show that the ozone enhancement is clearly shown in the middle and upper troposphere. We have found that the June maximum is associated with the transport of ozone rich air from the stratosphere and polluted continental air mass. This is different from the previous studies shown that the regionally polluted continental air mass, influenced by the intense anthropogenic activities in northeast Asia during transport, is responsible for the ozone maximum in spring.

Key words : Tropospheric ozone, Spring Maximum, Pohang

1. Introduction

Ozone in the troposphere plays very important roles in controlling the oxidizing capacity of the atmosphere as a primary precursor of the hydroxyl radical, producing global climate change as a greenhouse gas, and damagimg vegetation and human health as an air pollutant. Tropospheric ozone concentrations over East Asia have increased in the lower troposphere in recent decades due to increased anthropogenic emissions of ozone precursors released from a rapidly emerging industrialized Asian continent. This increase is not only within the region, but also downwind as ozone along with the precursors have been observed to be transported over the Pacific Ocean and to occasionally reach North America. Therefore there have been growing interest in tropospheric ozone study over Northeast Asia. The seasonal variations of surface ozone at Happo and Oki in Japan showed distinctive maximum in April and May. The trajectory analysis and CO/O_3 correlation studies have suggested that the regionally polluted continental air mass is responsible for the ozone maximum in spring. However, from tropospheric ozone study over the north Pacific using ozonesonde observations.[1] have found that the movement of the jet during the spring and early summer is associated with the influence of the timing of the seasonal maximum, and suggested that transport of ozone rich air from the stratosphere plays a strong role in the development of the spring maximum. This conclusion contradicts to the analyses at Oki and Happo. In this study, we present the analysis of vertical ozone sounding data observed over Pohang, Korea, and investigate to understand the governing mechanisms.

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2. Results and Discussion

2.1 Measurements

The vertical ozone profiles for this study were obtained from the balloon-borne ozonesonde, which is consists of an ozone sensor named the electrochemical concentration cell (ECC). The ECC ozonesondes were regularly launched about once a week at Pohang, Korea (36°N, 129°E) where is about the same latitude as of Oki and Happo, Japan. In this study, we have used sounding measurements with vertical resolution of 100m for the period between January 1995 and December 2000.

2.2 Results and Discussion

The time-height cross-sections of ozone mixing ratio and relative humidity show that the ozone concentration is very low and the tropopause height is the lowest in January and February. The ozone concentrations in the upper troposphere and the tropopause height are gradually increased starting from late March. As it approaches to June, the ozone enhancement is clearly shown in the middle and upper troposphere. For the period between late June and August, ozone concentrations in the low and middle troposphere have been reduced while relative humidity corresponding to these altitude ranges is significantly enhanced. Therefore, the anti-correlation between ozone and relative humidity suggests that the origin of water vapor can provide the clue for reduction of ozone concentrations. The period between late June and early September corresponds to the summer monsoon.

In order to analyze the seasonal variation of vertical ozone distribution in detail, we have taken an average over 1km interval. The variation between surface and 1km (surface layer) shows a primary peak in May and a secondary peak in September, while the variation of surface ozone at Oki shows a primary peak in April and a secondary peak in October. The month of the ozone primary peak shifts from May to June as it approaches from surface layer to layer-3 (between 2 and 3km). This can be explained by using the shift of wind direction between the surface layer and the top of boundary later near 1.5km. The prevailing westerly wind near surface becomes southerly in June, while the prevailing westerly wind above boundary layer does southerly a month later in July. This difference makes surface layer under influence of clean air a month earlier than above boundary layer.

We have used the analytic approach to find the origin of the ozone peak in June based in the fact that the air with the stratospheric origin has lower relative humidity than that with anthropogenic origin. In the surface layer, most of ozone is less than 50ppb and associated with relative humidity less than 50% for November-February, while ozone with a lot of variability is associated with relative humidity greater than 50% from July to September. This difference is due to the fact that Korea is under the influence of dry continental air mass in winter and spring, and wet marine air mass in summer. In layer-4 (between 3 and 4km), most of ozone is under extremely dry condition which is associated with relative humidity less than 40% except for July and August. The fact that ozone becomes higher and drier as the altitude increases indicates that the origin of the ozone is likely linked to the stratosphere. We have taken trajectory analysis to explain the origin of source. However, it is hard to use the trajectory analysis to pinpoint whether the layer ozone in the ozonesoundings is stratospheric or anthropogenic origin. Therefore, we used insentropic potential vorticity field over Pohang to analysis the origin. Potential Vorticity (PV) over 2.0PVU represents the stratospheric air. Also, the jet core induces the intrusion of stratospheric air into the troposphere. It is suggested that the stratosphere-troposphere exchange occurs over Pohang until June because Pohang is located in the backside of jet stream until June.

4. Conclusions

It is well known that most ozone measurements in the northern hemisphere show a spring maximum by two causes: transport from the stratosphere and photochemical ozone production. Previous studies have suggested that the regionally polluted continental air mass, influenced by the intense anthropogenic activities in northeast Asia during transport, is responsible for the ozone maximum in spring. However, this study is suggested that spring maximum is associated with the transport of ozone rich air from the stratosphere and polluted continental air mass.

References

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