Transport of Air Pollution and Tropospheric Ozone over China (TAPTO- China) during the Spring of 2004

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Abstract: - The Transport of Air Pollution and Tropospheric Ozone over China (TAPTO-China) is an ozonesonde observation campaign conducted by an international science team during spring (April-May) of 2004. The aim of this study is to determine the vertical distribution of tropospheric ozone over China in spring and to understand the impacts of pollutant transport and emissions on tropospheric ozone changes over South China as well as the chemical evolution of Asian outflow to the Pacific. This field campaign was also supplemented by surface measurements of ozone, carbon monoxide, nitrogen oxides, aerosol ($PM_{2.5}$ and PM_{10}). The collection of air and aerosol samples was followed by analysis for the chemical composition. The traditional air pollution over South China will be discussed. The major findings from this field campaign will also be presented and analyzed.

Key-Words: - TAPTO-China, Tropospheric Ozone, Air Pollution and South China.

1 Introduction

Understanding of the troposheric ozone is very important because, besides being a greenhouse gas, it is a precursor for the highly reactive hydroxyl radical, which affects the chemical composition and oxidizing capacity of the atmosphere. Ozone is also one of the secondary air pollutant which in high concentration is harmful to human and plant. In the lower troposphere, ozone is mainly produced by photochemistry involving pollutants which are released from various industrial and anthropogenic activities. Photochemical ozone production takes place through photoxidation of carbon monoxide (CO), volatile organic compounds (VOCs) and methane in the presence of sufficient amount of nitrogen oxide and sunlight.

TAPTO-China (Transport of Air Pollutants and Tropospheric Ozone over China) is a field campaign mainly based on in-situ ozonesonde observation campaign conducted by an international science team in April-May 2004 (www.cse.polyu.edu.hk/research/tapto-china/). So far, field measurements of key air pollutants in China have been comparatively sparse, especially in rural locations. The data collected will enable us to understand ozone pollution problem in China and to provide valuable data to elucidate atmospheric processes, to reconcile emission inventories, and to constrain regional chemical transport models.

2 Experiment

In the first phrase study of this field campaign, ozonesondes were simultaneously launched along the major subtropical air mass transport pathway extending from Southeast Asia to South China and the Central Pacific. The ozonesonde observation stations extended from southwest China in Tengchong (25.01^{o}N, 98.3^{o}E, 1640 m a.s.l.), Yunan Province, to South China in Sanya (18.40oN, 108.40^{o}E, 6 m a.s.l.), Hainan Island, to southeast China in Hong Kong (23.31^{o}N, 114.17^{o}E, 65 m a.s.l), and extended to East Aisan city in

Linan (30.30°N, 119.75°E, 132 m a.s.l.) as shown in Fig. 1.

This field campaign was also supplemented by surface measurements. Continuous measurements of ozone, carbon monoxide (CO), nitrogen oxides (NOx) and areosols (PM_{10} and $PM_{2.5}$) were peroformed on southeastern Tibetan Plateau at Tengchong (25.01°N, 98.3°E, 1960 m a.s.l.) in Southwest China in the spring of 2004. The aerosol samples collected by the Airmetrics Minivol Portable Samplers (mini-vol) were then followed by analysis for the chemical composition.

3 Results and discussions:

3.1 Surface ozone enhancements in South China

Surface O_3, CO, NOx, PM_{10} and $PM_{2.5}$ had average concentrations of 26 ppb, 179 ppb, 2.7 ppb, 28 and 34 µg/m^3 respectively. The springtime surface O_3, CO, NOx and aerosols levels over the Tibetan Plateau at Techgchong were low when compared with those reported for other rural and background sites in Asia in the same period of the year. However, high levels of pollution with hourly average O_3, CO, NO_x, PM_{10} and $PM_{2.5}$ concentrations up to 59, 678 and 7.7 ppb and 158 and 137µg/m^3 respectively were observed at the beginning of May. The 3-dimensional backward air trajectories calculated by the National Oceanic and Atmospheric Administration (NOAA) HYSPLIT Model (Draxler and Rolph, 2003; Rolph, 2003) were used to pinpoint the source region of air masses. The air masses at the surface were originated from the close vicinity of the Bay of Bengal and passed over Bangladesh, Bhutan and yanmar region in the close neighborhoods of Tengchong, where active fires were detected by the fire count maps from MODIS (Moderate Resolution Imaging Spectroradiometer) satellite image. The physical approaches by the back air trajectory and fire map suggested that it was the result of photochemical O_3 formation and accumulation involving the high levels of O_3 precursors during the transboundary transport to Southwest China under favorable meteorological conditions.

Water-soluble potassium (K^+) is a typical component of biomass burning aerosol. In order to clearly identify the source of air masses in our episode cases, K^+ has been used as tracer element for the qualitative identification of biomass burning (Cachier et al., 1991; Chow, 1995). The averages of K^+ in our sampling period were 0.18 ug/m^3 for $PM_{2.5}$ samples and 0.23 ug/m^3 for PM_{10} samples, ranging from 0.03 - 0.43 and 0.04 - 0.55 ug/m^3 for $PM_{2.5}$ and PM_{10} samples respectively. However, high values of K^+ were observed on May 4 to May 6 (Fig. 2), which was consistence with our episode case mentioned before, strongly suggesting that the ozone and its precursors were originated from biomass burning.

3.2) Tropospheric ozone enhancement in South China

Abnormal crude oil open burnings are large source emissions on a global scale in comparison to other sources, such as mobile and industrial sources. In 21 March 2003, the Iraq War started and quickly ended in May 2003. However, terrorist attacks by the extremist groups were frequently reported with the oil pipeline network systems in Iraq one of the targets of sabotage (Geotimes December, 2004). Significant emission of ozone precursors are found transported downwind resulting from crude oil open burning.

During the TAPTO experimental period in spring of 2004, vertical ozone profile measurements were obtained from ozonesondes launched on three sites of South China at Tengchong in Yunan Province, Sanya in Hainan Province and Hong Kong in the southwest of Guangdong

Province. There were totally 63 ozonesondes launched on these three sites from 2 April to 21 May 2004. The average ozone concentrations over South China ranged from 50 to 75 ppb in the middle troposphere (Fig. 3). Surprisingly, high ozone mixing ratios were simultaneously observed in the middle troposphere at the three launching stations with 150 ppb at Tengchong, 110 ppb at Sanya and 150 ppb at Hong Kong during 7-10 May (Fig. 4). Backward air trajectories were used to trace the source of the air masses. Analysis indicated that the air masses traversed the Persian Gulf including Iraq, Iran and Saudi Arabia before reaching those sites. Significant hot spots were simultaneously observed by the ATSR World fire Atlas around Iraq with characteristic low Relative Humidity (RH). Traditionally, biomass burnings in spring from agriculture activities in Southeast Asia have been reported to be the major contributor of ozone enhancement with characteristic high RH in South China. In this study, we demonstrated that crude oil open burning activities in Middle East could have significant impact on the middle troposphere over South China and may have an even greater regional impact when these air masses eventually outflow to the Western Pacific.

4 Conclusion

The major findings in the TAPTO-China ozonesonde observation field campaign have been discussed. Our study in the surface measurements describes and interprets chemical measurements taken on the Tibetan Plateau of southwest China, a region that previously had been devoid of such measurements. This study also provided the information to fill the gap in one of vacuum area of the Eurasian continent. Also, the impacts of the biomass burning activities in South and Southeast Asia have been assessed. In the tropospheric ozone measurement, the traditional ozone enhancement in South China was caused by SE Asian biomass burning emissions due to the agricultural land scavenging and accidental forest fire in neighborhood countries. This study indicates that the open burning activities in the Persian Gulf region could also have significant effect on ozone enhancement in South China.

Acknowledgments

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Fig. 1) Map showing the ozonesonde launching stations in Tengchong, Sanya, Hong Kong and Linan.

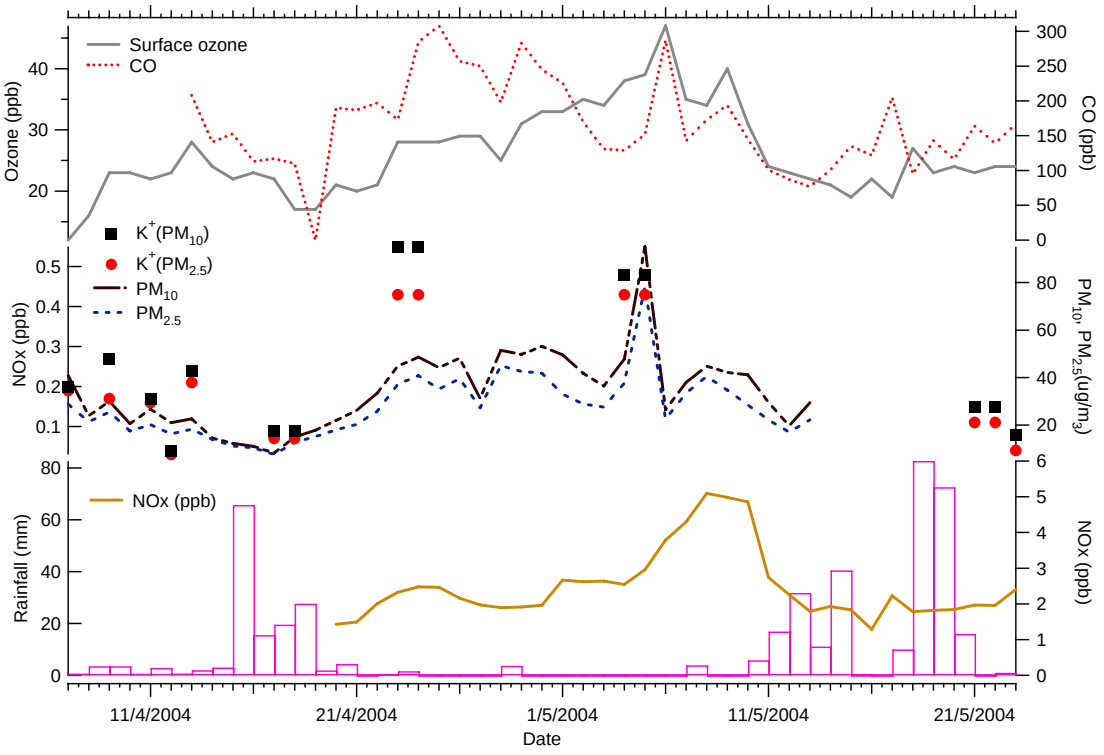

Fig. 2) Daily average concentrations of O_3, CO, NOx, PM_{10}, $PM_{2.5}$, water-soluble potassium ions and rainfall in the sampling period.

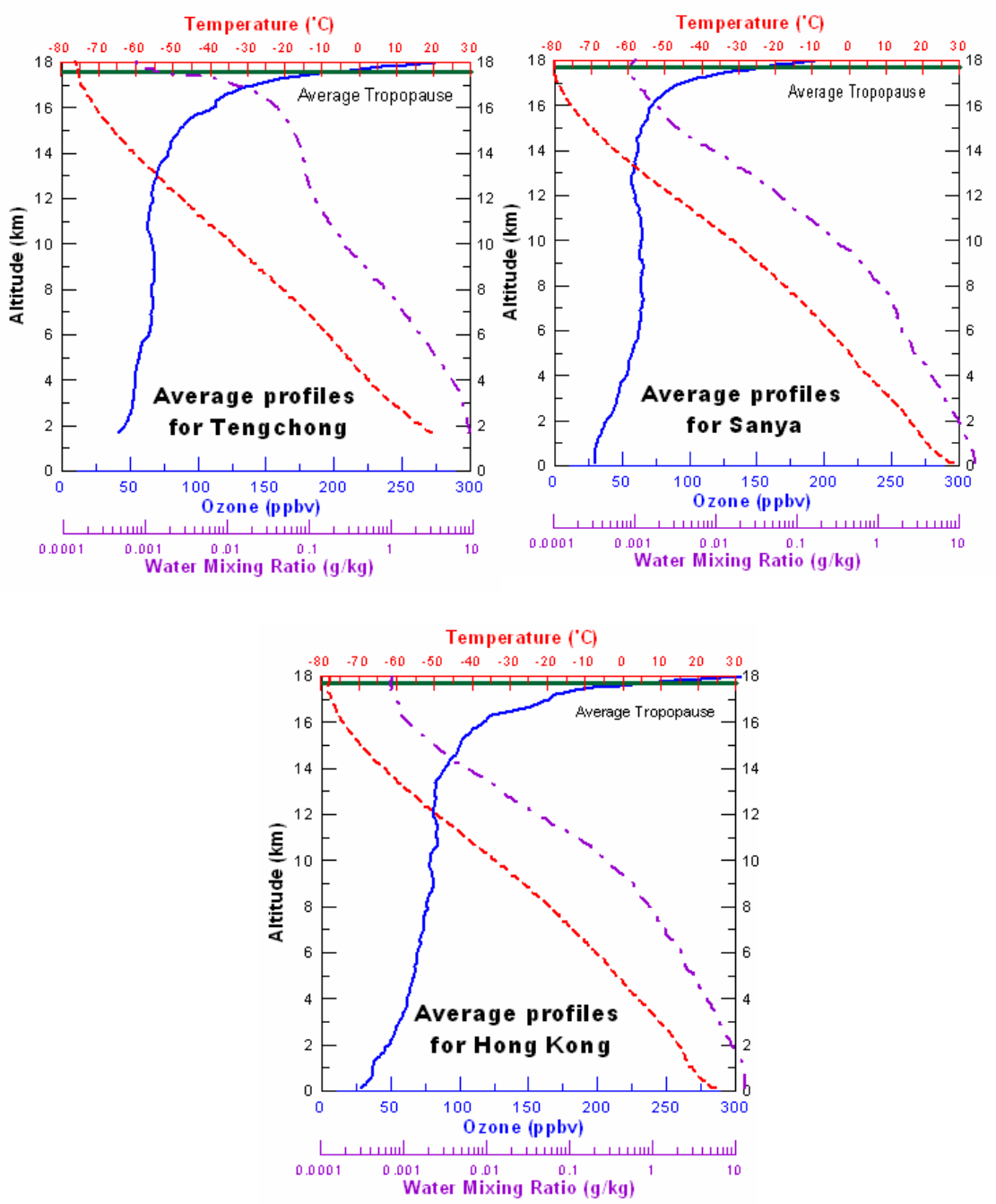

Fig. 3) The average profiles of ozone (solid line), water mixing ratio (dash-dot line) and temperature (dash line) over Tengchong, Sanya and Hong Kong. The tropopause heights are marked by horizontal solid lines.

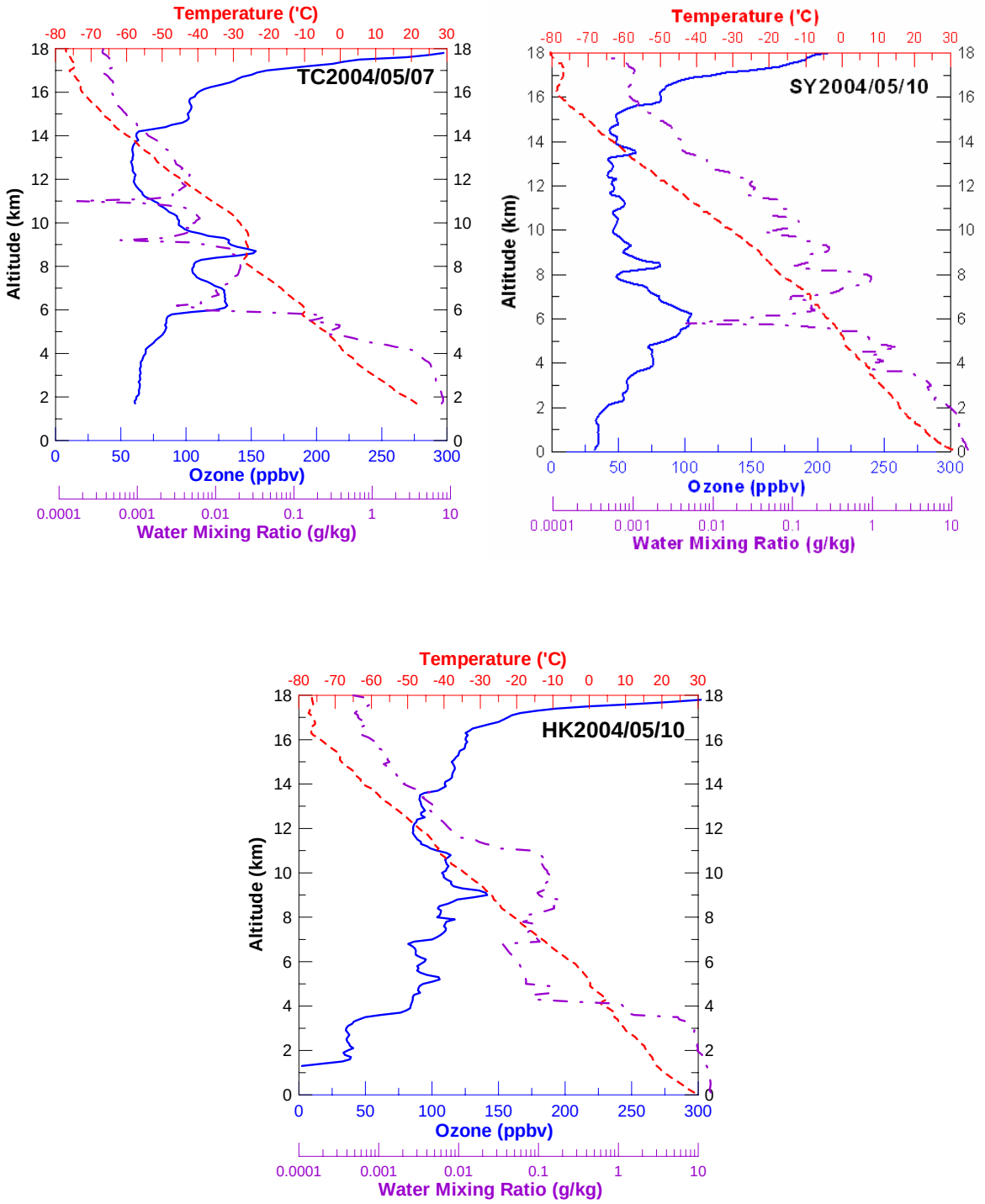

Fig. 4) Abnormal ozone enhancements in the middle troposphere over Tengchong, Sanya and Hong Kong during 7-10 May.