

Firstly, we thank you very much for your valuable and encouraging comments and suggestions, which lead to a significant improvement of our manuscript. The detailed responses to each comment are listed below:

The text with italics indicates the reviewer's comments, and the normal text is our response.

Anonymous Referee #2

1. Your citation is not enough, please add some new result of ozone in Shanghai and YRD region in recent year.

Reply: We insert more references here:

P2, Line 19–23, ... As a result, an increase in the frequency of ozone pollution events has been observed in the lower troposphere during the photochemically active seasons in these developing suburban and rural areas, suggesting significant detrimental effects of pollution on regional air quality (e.g., Gao et al., 2005; Wang et al., 2006; **Tie et al., 2009**; Dufour et al., 2010).

We Tie, X., Geng, F., Peng, L., Gao, W., and Zhao, C.: Measurement and modeling of O₃ variability in Shanghai, China: Application of the WRF-Chem model, Atmos. Environ., 43, 4289-4302, 10.1016/j.atmosenv.2009.06.008, 2009.

P8, Line 20–22, insert one sentence: Wang et al., (2011) also suggest that Chinese pollution ozone has a peak of 20–25 ppbv in June north of the Yangtze River, which explains the peaks of high ozone concentrations in the lower troposphere in June.

Wang, Y., Zhang, Y., Hao, J., and Luo, M.: Seasonal and spatial variability of surface ozone over China: contributions from background and domestic pollution, Atmos. Chem. Phys., 11, 3511-3525, doi:10.5194/acp-11-3511-2011, 2011.

2. Please give more evidence or citation to support your conclusion in line 24-25 of page 6 and in line 17-18 of page 7.

P7, Line 3–5: ...Near the tropopause, downward propagation of enhanced ozone

values from the lower stratosphere to the upper troposphere was frequently observed during spring and summer.

Reply: Figure 1a is the monthly mean ozone profiles from ozonesonde observation during 2002–2010 in Beijing. From this figure we can see the phenomenon that the enhanced ozone values (e.g., 120–160 ppbv contours) cross the first thermal tropopause (LRT1) and downward propagation to the upper troposphere during spring and summer. Based on this phenomenon, we gave this conclusion. And, the model simulation in the paper (Fig. 1b) also supports this result.

P7, Line 23–24: ...In particular, during spring and summer, ozone-rich air is strongly transported downward from the stratosphere into the troposphere...

Reply: In order to isolate the transport effect in the model simulation, a CLaMS simulation without ozone chemistry (CLaMS-PO₃: Passively transported ozone) is considered. In the troposphere, enhanced ozone values of CLaMS simulation can only originate from the stratosphere (Fig. 1b). So we say, “...during spring and summer, ozone-rich air is strongly transported downward from the stratosphere into the troposphere...”.

3. In line 8-9 of page 8, a thin layer with a reduced ozone gradient is located below LRT2. Please mark the thin layer on the Fig.2.

P8, Line 12–14: From winter to early summer, a layer with an enhanced ozone gradient (2–4 km) exists above LRT1, and a thin layer with a reduced ozone gradient is located below LRT2.

Reply: We showed the thin layer with a red arrow in the Fig. 2c, d (see below).

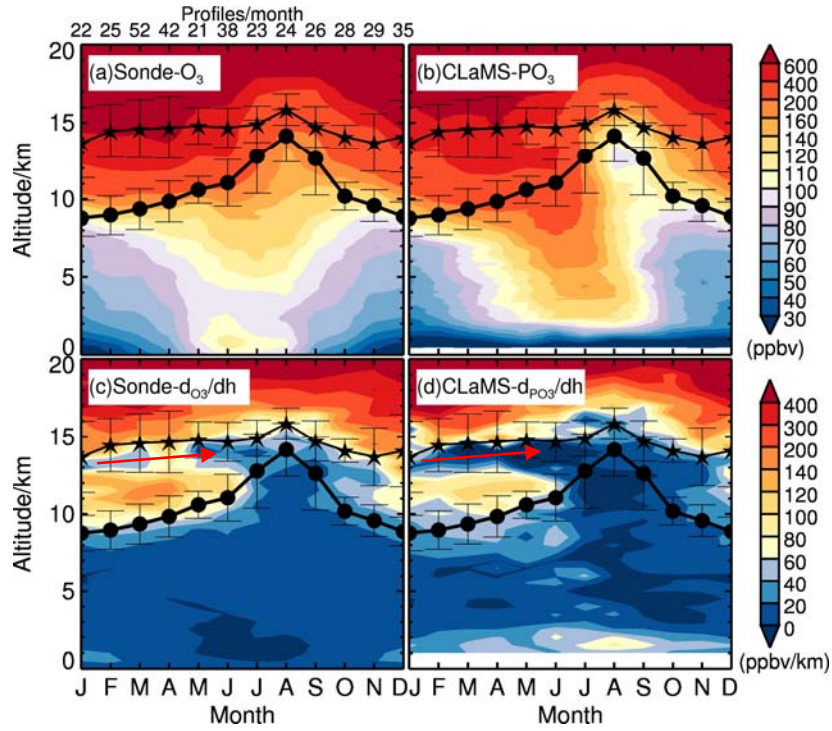


Fig. 2. The seasonality of ozone from (a) ozonesonde observation, (b) CLaMS- PO_3 (passively transported ozone) from CLaMS simulation at the time and location of the measurement, and their corresponding (c, d) vertical gradients during 2002–2010 at Beijing. The first (LRT1) and second (LRT2) thermal tropopauses are shown as a thick line with solid dots and stars, respectively. The error bars are standard deviations ($\pm\sigma$). The red arrow shows a thin layer with a reduced ozone gradient below LRT2.