Variations of ground-level O_3 and its precursors in Beijing in summertime between 2005 and 2011 (acp-2013-977)

Response to Referee #1

Zhang et al.

Zhang et al. present a time-series of measurements of NOx, VOC and ozone taken between 2005 and 2011 at a single location in Beijing. They show that both ozone and total oxidants (ozone, NO2, and other reservoir species of reactive nitrogen) have been increasing while both NOx and VOC were decreasing. The authors discuss their measurements in the context of emission control strategies which have been implemented in Beijing, and of other measurement data for Beijing, including satellite measurements. I would like to see some discussion of how well the measurement site at PKU is representative of the rest of Beijing. The authors describe the situation of the site and its local sources well, but I would like to see some wider context here.

Response: Yes, the representativeness of the site is indeed a key issue for a study on variation. The monitoring site on campus of Peking University locates about 20 km northwest of the Tiananmen Square. The site was selected to be built on the 6 floor of a building, about 18 m above ground surrounded by the Zhongguancun Avenue and the 4th-ring road with high traffic density. Ozone chemistry had been measured at the site from 1982 (Shao et al., 2006). This site was considered to be representative for the urban environment of Beijing city after an intensive campaign in Beijing where the air pollutants including ozone and PM2.5 were measured in August at more than 10 sites in Beijing. And this was the reason why Peking University chose this site as a long-term observatory for air pollution and climate change in 2004. This site has been used in several large-scale field campaigns for air quality program in North China Plain, including

the one for 2008 Beijing Olympics. The description of the site and measurement technologies at the site could also be seen elsewhere (Wehner et al., 2008;Zhang et al., 2012).

For this work, we compiled ambient ozone and its precursors' mixing ratios in Beijing from 2005 to 2011 for a trend analysis of ozone chemistry.

Using measurements and a simple box model, the authors calculate the total oxidant production rate in Beijing between 2001 and 2011. It is not clear to me which data are used before 2005, as the authors' own dataset only begins in 2005. The authors should mention more explicitly which data are used as input to their model.

Response: The data of ozone and its precursors (NO/NO_2, VOCs) were from our measurements at the site on campus of Peking University. The data used in the model before 2006 were from literatures: the publication (Wang et al., 2012) summarized VOCs in Beijing between 2000 and 2007; NO_x (NO, NO_2) in Beijing were summarized from the data in Beijing Municipal Environmental Monitoring Center (Tang et al., 2009). The data source and the way we performed the data processing were explained in our revised version.

Using this method, the authors calculate an increase in P(Ox) from 2001 to 2006, consistent with the observed increase in ozone, but their calculation of a basically unchanged P(Ox) between 2006 and 2011 is not consistent with observations. The authors discuss this discrepancy in terms of the limitations of their method, in particular the lack of comprehensively speciated VOC input data including formaldehyde and other OVOCs. The authors suggest that better measurement of OVOCs for Beijing are required to better understand recent ozone production, which seems like a reasonable recommendation due to their role in oxidant production through their photolysis and associated radical production.

Response: Thanks for the comment. The discrepancy between calculated P(Ox) and observed Ox could result from two aspects of limitations in this method. One is the lack

of some reactive VOC species like ethene and formaldehyde etc.. The other one is the role of regional background of ozone. If the contributions from regional ozone and its precursors also change significantly, it will be problematic to explain ozone or Ox trend only by this formula. We examined the change in regional background and surmised that the influence could be minor comparing with photochemistry in Beijing area. We will perform more quantitative studies on VOCs reactivity and regional background ozone.

Elsewhere in the paper (Sect. 3.2), the authors mention the possibility of increased regional ozone production in the North China Plain due to changing emissions patterns, in particular the increased NOx emissions associated with power stations in this region. In my opinion the authors should give more weight to the possibility that ozone pollution in Beijing is becoming more of a regional problem, than just a matter of local photochemistry.

Response: Fully agree. Ozone pollution in Beijing could be more influenced by regional change due to stringent control of air quality in Beijing. However, it is difficult to quantify this regional contribution precisely. We made a simplified estimation based on the work of Meng et al. (2009) and Wang et al. (2009) about variations of ozone background in the Northern or Eastern China. Ozone in these two remote sites increased by 1.0 ppbv yr^{-1} and 0.58 ppbv yr^{-1}, respectively. We assumed that regional ozone background in the North China Plain increased at the rate between 0.58-1.0 ppbv yr^{-1}. Therefore, changes of regional background may account for 22-38% of total 2.6 ppbv yr^{-1}. This was explained in the text. As the central government is pushing harmonized regional development in Beijing-Tianjin-Hebei area, the regional air quality will be more required for further studies.

In general, the paper is clearly and concisely written and certainly suitable for publication in ACP once the authors address the above minor concerns.

Response: Appreciate the encouragement.

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