Response to Anonymous Referee #2

General comments:

This work focuses on the ozone pollution in four large cities of China. Observation based methods are used in the analyses to understand the impacts of photochemistry, regional transport and deposition. In addition, some heterogeneous processes are considered and preliminary results show that they might be important to local ozone levels and should be incorporated into photochemical mechanisms.

Response: we thank the reviewer for the helpful comments and suggestions. We have revised the manuscript accordingly and address the specific comments below.

Specific comments:

1. *Site selection: The four sites are rural or suburban, not far from large cities (the biggest distance is about 50 km from the cities). However, the Beijing site is different in nature from other three sites, i.e. it's a pure rural mountain site and is the most distant from cities of the four sites. These features determine that the Beijing site is dominated by distant/regional transport, and the photochemical evolution processes (including the heterogeneous processes) might not be reflected by precursor concentrations observed. On the other hand, at this rural site the authors observed/recorded the highest ozone concentration (286 ppbv) in the area, which may not occur at a suburban site. It would be clearer if the authors explain the differences of the results between Beijing site and other three sites caused by the site locations.*

Response: yes, the difference in the type of station between Beijing site and the other three sites determines to a large extent the differences of the results. For clarity, the following statements have been added in the revised manuscript (Section 2.1).

"The rural nature of the site determines to a large extent the 'unique' results obtained in Beijing (i.e., highest O_3, lowest O_3 precursors, and dominant role of regional transport) compared to the other three cities (suburban sites), which should be kept in mind when comparing the results among the four sites."

2. *Model validation: The observed based box model used to quantify the in-situ ozone production is built on the MCM v3.2 mechanism. However, no model validation results are provided in the manuscript.*

Response: the OBM is usually used to calculate the chemical reaction rates and simulate the highly reactive species, based on the known chemical kinetic data and high-quality measurements. The model has been successfully utilized for this purpose in many previous studies such as Xue et al. (2013), Xue et al. (2014a) and Xue et al. (2014b). The following statement has been added in the revised manuscript.

"The model has been successfully applied in the previous studies (Xue et al., 2013, 2014a and 2014b)."

Xue, L. K., Wang, T., Guo, H., Blake, D. R., Tang, J., Zhang, X. C., Saunders, S. M., and Wang, W. X.: Sources and photochemistry of volatile organic compounds in the remote atmosphere of western China: results from the Mt. Waliguan Observatory, *Atmos. Chem. Phys.*,13, 8551-8567, 2013.

Xue, L. K., Wang, T., Louie, P. K. K., Luk, C. W. Y., Blake, D. R., and Xu, Z.: Increasing external effects negate local efforts to control ozone air pollution: a case study of Hong Kong and implications for other Chinese cities, *Environ. Sci. Tech.*, 48 (18), 10769-10775, 2014a.

Xue, L. K., Wang, T., Wang, X. F., Blake, D. R., Gao, J., Nie, W., Gao, R., Gao, X. M., Xu, Z., Ding, A. J., Huang, Y., Lee, S. C., Chen, Y. Z., Wang, S. L., Chai, F. H., Zhang, Q. Z., and Wang, W. X.: On the use of an explicit chemical mechanism to dissect peroxy acetyl nitrate formation, *Environ. Pollution*, 195, 39-47, 2014b.

3. *The Guangzhou site: Some parameters were not observed at this site and took observations of same season at Tung Chung, Hong Kong. The authors did not mention which parameters were not measured at Guangzhou site. For some parameters, e.g. aerosol properties, there might be differences between Guangzhou and Hong Kong. It would be convincing if comparisons are provided when data sources are available (like $PM_{2.5}$ measurements by the Hong Kong EPD and Guangzhou EPB) for the two sites or cities.*

Response: the aerosol surface area was not measured at the Guangzhou site (Wanqingsha), and we used the measurements collected at Tung Chung. To our knowledge, measurements of aerosol size distribution are still not available at the Wanqingsha site, while PM_{10} mass concentrations have been routinely monitored since 2006 by the Pearl River Delta Air Quality Monitoring Network that includes both Wanqingsha and Tung Chung. According to the monitoring results, the PM_{10} level at Wanqingsha was about 30% higher than that at Tung Chung (http://www.gdep.gov.cn/hjjce/). For example, the annual mean PM_{10} concentration at Wanqingsha was 89 $\mu g/m^3$ in 2006, compared to that of 61 $\mu g/m^3$ at Tung Chung.

To evaluate the uncertainty of our base model results, we conducted a sensitivity study by magnifying the aerosol surface area by 50% (the adjusted levels are still much lower than those of Beijing and Shanghai, but comparable to those of Lanzhou). The results indicate that its impact on the modeling results is insignificant (i.e., ~1% in net O_3 production rates). The following statements have been added in the revises manuscript.

"The aerosol surface and radius were calculated from the aerosol number and size distribution measurements. For Guangzhou where such measurements were not available, we used the average diurnal data obtained from a similar suburban site in Hong Kong (Tung Chung, close to the WQS site; see Fig. S1) in the same season (May 2012). Sensitivity studies using 50% higher aerosol surface indicated little impact on the modeling results (i.e., ~1% in net O_3 production rate)."

Technical corrections: The writing of the manuscript is acceptable.