Reply to Anonymous Referee #2

We thank the reviewer for the careful reading of our manuscript and helpful comments. We have revised the manuscript following the suggestion, as described below.

Major Comments:

1) This study provides a WRF-CHEM analysis of ozone and $PM_{2.5}$ pollution in Xi'an, China over a short time period of 3-days. If this type of urban study focusing on just 3 days were conducted for an urban area in the US or Europe it would not have a level of significance that would warrant publication in ACP. But because this study focuses on China, the fastest growing emissions region on the planet with enormous implications for tropospheric chemistry and trace gas budgets, the study is appropriate for ACP. Therefore my main recommendation to the authors is to devote less space to describing the details of the model/measurement comparison, and spend more time discussing or emphasizing the results that have implications for future atmospheric chemistry research: comparison of Xi'an ozone and $PM_{2.5}$ to other region in China, the difficulties of controlling $PM_{2.5}$ which then boosts ozone production, describing the full seasonal cycle of ozone at Xi'an. Specifically, the abstract and conclusions are quite long and can be shortened by reducing the model/measurement comparison which is adequately covered in the main text.

We have compared the summertime O_3 and $PM_{2.5}$ concentrations in Xi'an to those in the main cities of BTH, YRD, and PRD, and included a paragraph on Page 8: "*Table 2 shows the comparison of summertime O_3 and $PM_{2.5}$ concentrations (averaged in the afternoon) in Xi'an to the main cities of BTH, YRD, and PRD in China during 2013. The O_3 and $PM_{2.5}$ concentrations in cities of BTH are much higher than those in Xi'an, showing the heavy air pollution in BTH. Due to the impact of frequent precipitation in South China, the $PM_{2.5}$ concentrations in the cities of YRD and PRD are lower than those in Xi'an, but the O_3 concentrations in Shanghai and Hangzhou are still higher than those in Xi'an. Generally, the air quality in Xi'an is better than that in the cities of BTH, but worse than that in Guangzhou of PRD.*"

Table 2 Summertime O_3 and $PM_{2.5}$ concentrations (averaged in the afternoon) in the main cities of Guanzhong basin, BTH, YRD, and PRD in China during 2013.

Region	City	O_3 (μg m^{-3})	$PM_{2.5}$ (μg m^{-3})
Guanzhong	Xi'an	104.6	48.5
BTH	Beijing	133.9	74.7
	Tianjin	116.9	78.1
	Shijiazhuang	140.4	86.6
YRD	Shanghai	122.9	47.1
	Hangzhou	110.5	35.0
	Nanjing	96.6	41.2
PRD	Guangzhou	94.9	29.4

We have included a paragraph to discuss the difficulties of controlling $PM_{2.5}$ which then boosts ozone production on Page 22: "*Since the release of "Atmospheric Pollution Prevention and Control Action Plan" in 2013 (http://www.gov.cn/zwgk/2013-09/12/content_2486773.htm), the stringent $PM_{2.5}$ control strategy has been implemented in China. The summertime $PM_{2.5}$ concentration in the afternoon in Xi'an has decreased from 48.5 μg m^{-3} in 2013 to 38.8 μg m^{-3} in 2014; however, the O_3 concentration has increased from 104.6 μg m^{-3} in 2013 to 114.7 μg m^{-3} in 2014. The same trend is also found in the cities of BTH: the $PM_{2.5}$ concentration has decreased from 71.5 μg m^{-3} in 2013 to 57.4 μg m^{-3} in 2014, while the O_3 concentration has increased from 125.8 μg m^{-3} in 2013 to 139.1 μg m^{-3} in 2014. Therefore, the decrease of the $PM_{2.5}$ level might enhance O_3 production, which is consistent with the results in the present study.*"

We have added a paragraph to describe the full seasonal cycle of ozone at Xi'an on Pages 7-8: "*Figure 4 further presents the monthly minimum, 5th percentile, median, 95th percentile, and maximum observations of near-surface O_3 concentrations in the afternoon averaged over 13 sites in Xi'an during the period from April 2013 to March 2014. The seasonal cycle of O_3 levels in Xi'an shows high summertime O_3 concentrations, which is consistent with that in North China Plain (Cooper et al., 2014). In the study of Cooper et al. (2014), the midday O_3 mixing ratio in North China Plain peaks in June and then decreases in July and August due to the southerly monsoon flow. However, during the summer of 2013, the median O_3 concentration in the afternoon in Xi'an increases progressively from about 90 μg m^{-3} in June to 120 μg m^{-3} in August, with the maximum increasing from about 170 μg m^{-3} in June to 210 μg m^{-3} in August, which is possibly caused by the inland location of Xi'an with less monsoon precipitation during summertime.*"

We have shortened the abstract on Page 1 and conclusions on Page 20 as suggested.

2) Greater context of the Xi'an region and ozone observations needs to be given in relation to China, the US and Europe. Please expand Figure 1 by showing a map of all China and the location of Xi'an so the reader can understand that this city is far from the urban areas of Beijing and Shanghai. It would also be very helpful if you can show the seasonal cycle of ozone in Xi'an by plotting the monthly median, 5th percentile and 95th percentile for daytime observations. Then the reader can understand how the ozone observations in this study fall in relation to typical conditions. For example, in the North China Plain ozone peaks in June and then decreases in July and August due to the southerly monsoon flow. Does the same pattern occur at Xi'an? Are the high ozone values in August in Xi'an less than the values in June? Also the reader will then be able to compare Xi'an to the regionally representative sites in northern China, the USA and Europe as shown in the recent review paper:
Cooper et al. (2014), Global distribution and trends of tropospheric ozone: An observation-based review, Elementa: Science of the Anthropocene, 2, 000029, doi: 10.12952/journal.elementa.000029
See their Figure 10 http://www.elementascience.org/articles/29

We have updated Figure 1 on Page 35 to clearly show the relative situations of Xi'an, Beijing, and Shanghai in China. We have included a paragraph to describe the seasonal cycle of O_3 in

Xi'an on Pages 7-8: "*Figure 4 further presents the monthly minimum, 5th percentile, median, 95th percentile, and maximum observations of near-surface O_3 concentrations in the afternoon averaged over 13 sites in Xi'an during the period from April 2013 to March 2014. The seasonal cycle of O_3 levels in Xi'an shows high summertime O_3 concentrations, which is consistent with that in North China Plain (Cooper et al., 2014). In the study of Cooper et al. (2014), the midday O_3 mixing ratio in North China Plain peaks in June and then decreases in July and August due to the southerly monsoon flow. However, during the summer of 2013, the median O_3 concentration in the afternoon in Xi'an increases progressively from about 90 μg m^{-3} in June to 120 μg m^{-3} in August, with the maximum increasing from about 170 μg m^{-3} in June to 210 μg m^{-3} in August, which is possibly caused by the inland location of Xi'an with less monsoon precipitation during summertime.*"

3) No description is provided of the methods used to make the observations of ozone, NO_2 and $PM_{2.5}$. Instruments? Institutions? Were the data checked for quality and reliability?

We have added a paragraph to describe the methods used to make the observations of O_3, NO_2, and $PM_{2.5}$ on Page 6: "*The real-time hourly measurements of O_3, NO_2, and $PM_{2.5}$ used in this study are released by China MEP and can be accessed from the website http://106.37.208.233:20035/. The historical profile of the observed ambient pollutants can be accessed at http://www.aqistudy.cn/. The O_3, NO_2, and $PM_{2.5}$ concentrations are measured by using Model 49i Ozone Analyzer, Model 42i (NO-NO_2-NO_x) Analyzer, and Model 5030 SHARP Monitor from Thermo Fisher Scientific, USA, respectively. All the instruments are maintained and routinely calibrated by China MEP to assure data quality.*"

4) According to the ACP data policy, the underlying chemical observations used in the analysis should be publicly available, as described here:
Statement on the availability of underlying data: http://www.atmospheric-chemistry-and-physics.net/about/data_policy.html#data_availability "Authors are required to provide a statement on how their underlying research data can be accessed. This must be placed as the section "Data availability" at the end of the manuscript before the acknowledgements."
This paper contains no data availability statement and the authors need to provide one. I am bringing this up because there is great interest within the atmospheric chemistry community regarding the quantity of ozone produced in East Asia as well as the ozone produced by East Asian emissions once the pollutants have been exported from the continent. With ozone pollution decreasing in North America and Europe, East Asia is the main driving force behind any increase in tropospheric ozone. By having access to the ozone and ozone precursor observations described in this paper the scientific community can further its understanding of the global tropospheric ozone budget. It would be a great service to the community if the authors of this paper can make available the ozone and precursor data for at least a full year, rather than just the 3 days described in the paper. The authors can provide a further valuable service to the research com- munity by uploading the hourly ozone

observations to the database of IGAC's Tropospheric Ozone Assessment Report (TOAR): http://www.igacproject.org/TOAR. One of the goals of TOAR is to calculate ozone metrics at thousands of surface sites around the world relevant for research on ozone's impact on human health, vegetation and climate change. With so little data publicly available from East Asia, the data in this paper would be of great benefit to TOAR.

We have included "Data availability" on Page 23: "*Data availability: The real-time O_3, NO_2 and $PM_{2.5}$ are accessible for the public on the website http://106.37.208.233:20035/. One can also access the historic profile of observed ambient pollutants through visiting http://www.aqistudy.cn/.*"

5) The standard of English in the manuscript needs to be greatly improved. The paper has too many grammatical and word-choice errors for me to correct and I recommend that the authors either find a colleague with excellent English skills to edit the grammar line-by-line, or employ the assistance of an ACP journal copy-editor.

We have revised the manuscript carefully and corrected the errors as suggested. In addition, our co-author Dr. Luisa T. Molina, has edited the grammar carefully.

Minor Comments:

1) Abstract, page 30564 line 27 I'm not sure what you mean by "manifest changes of the emission inventory". Manifest means obvious, is that what you mean to say? Also, is it the inventory of the emissions that has changed, or the actual emissions that have changed? The inventory is the documentation of the emissions, and from what I can infer from your paper, the inventory is out of date because the actual emissions have changed faster than the inventory can be updated. I think what you mean to say is Further studies need to be performed for O_3 control strategies considering the rapid changes in emissions that are not reflected in the available emission inventories, and uncertainties of meteorological field simulations.

We agree with the reviewer's comments that the inventory is out of date because the actual emissions have changed faster than the inventory can be updated. We have updated sentence on Page 1 as suggested: "*Further investigation on O_3 control strategies will need to be performed, taken into consideration the rapid changes in anthropogenic emissions that are not reflected in the current emission inventories, and the uncertainties in the meteorological field simulations.*"

2) Page 30582, lines 9-11 I don't understand what this sentence is trying to convey due to poor sentence structure. I think the word "whether" is used incorrectly. "The industry emissions contribute the most to the O_3 concentrations in Xi'an and surrounding areas, but whether individual anthropogenic emissions or biogenic emissions do not play a dominant

role in the O_3 formation. ”

We have corrected the sentence on Page 21: “*The industrial emissions contribute the most to the O_3 concentrations in Xi’an and surrounding areas, but neither individual anthropogenic emission nor biogenic emissions play a dominant role in the O_3 formation.*”

3) Page 30583 lines 11-13 Please provide a reference for the claim that O_3 is now the major summertime pollutant in the Beijing region.

We have rewritten the sentence and included a paragraph on Page 22: “*The summertime $PM_{2.5}$ concentration in the afternoon in Xi’an has decreased from 48.5 μg m^{-3} in 2013 to 38.8 μg m^{-3} in 2014; however, the O_3 concentration has increased from 104.6 μg m^{-3} in 2013 to 114.7 μg m^{-3} in 2014. The same trend is also found in the cities of BTH: the $PM_{2.5}$ concentration has decreased from 71.5 μg m^{-3} in 2013 to 57.4 μg m^{-3} in 2014, while the O_3 concentration has increased from 125.8 μg m^{-3} in 2013 to 139.1 μg m^{-3} in 2014.*”

4) Table 2: What are the sources of the ozone and $PM_{2.5}$ data from all of these cities?

We have added a paragraph to introduce the sources of the O_3 and $PM_{2.5}$ data on Page 6: “*The real-time hourly measurements of O_3, NO_2, and $PM_{2.5}$ used in this study are released by China MEP and can be accessed from the website http://106.37.208.233:20035/. The historical profile of the observed ambient pollutants can be accessed at http://www.aqistudy.cn/.*”

5) Figure 6 and 7 and 10: The squares indicating observed values are too small and need to be larger.

The squares have been updated as suggested.