Response to comments #2

RC2 comments:
General comments:
This is a manuscript delivering important messages towards China's air quality policymaking. They found that crop yield damages due to ozone air pollution have increased in recent years and are especially large for wheat and rice. Accumulatively, the economic losses are substantial, i.e. around ~20 billion USD for major crops during the past 8 years. Findings of this study indicate that improving China's ozone air quality can benefit food security, in addition to human health which has been the dominant driver of previous clean air policies. This reviewer works broadly in the arena of atmospheric chemistry and policy-relevant science instead of being an expert on vegetation impacts of ozone, thus will only judge based on best expertise. This reviewer recommends the acceptance of this manuscript if the following comments can be sufficiently addressed.
Response: We thank the reviewer's very positive comments of our study! We provided detailed responses below (reviewers' comments in plain font, our replies in blue). We really appreciate the reviewers' time.

Specific comments:
Introduction:
In the first paragraph, it is worth adding the mechanisms of observed increasing ozone concentrations in China. The reasons include not only increasing anthropogenic VOC emissions but also decreased ozone titration due to decreased NOx emissions especially in megacities where ozone production is usually NOx-saturated. It is worth reviewing relevant literature.
Response: We thank the reviewer's suggestion. We now add the following discussion at the end of first paragraph:
"The increasing trend of surface ozone may be partially explained by the decreased titration due to the decreased NO_X emissions especially in megacities (Liu et al., 2020a, b; Tan et al., 2020; Li et al., 2022), or the decreasing $PM_{2.5}$ which scavenges the radical precursors of ozone (Li et al., 2019a, 2020)."

Reference:

Li, K., Jacob, D. J., Zhang, Q., Liao, H., Bates, K. H. and Shen, L.: Anthropogenic drivers of 2013–2017 trends in summer surface ozone in China, Proc. Natl. Acad. Sci., 116(2), 422–427, doi:10.1073/pnas.1812168116, 2019a.

Li, K., Jacob, D. J., Shen, L., Lu, X., De Smedt, I., and Liao, H.: Increases in surface ozone pollution in China from 2013 to 2019: anthropogenic and meteorological influences, Atmos. Chem. Phys., 20, 11423–11433, https://doi.org/10.5194/acp-20-11423-2020, 2020.

Li, X., Yuan, B., Parrish, D. D., Chen, D., Song, Y., Yang, S., Liu, Z. and Shao, M.: Long-term trend of ozone in southern China reveals future mitigation strategy for air pollution, , 269(November 2021), 2022.
Liu, Y. and Wang, T. (2020a). Worsening urban ozone pollution in China from 2013 to 2017 – Part 1: The complex and varying roles of meteorology. Atmospheric Chemistry and Physics, 20(11), 6305–6321. https://doi.org/10.5194/acp-20-6305-2020.

Liu, Y. and Wang, T. (2020b). Worsening urban ozone pollution in China from 2013 to 2017 – Part 2: The effects of emission changes and implications for multi-pollutant control. Atmospheric Chemistry and Physics, 20(11), 6323–6337. https://doi.org/10.5194/acp-20-6323-2020.

Line 48-54. Literature seems to find very large yield decrease effects for soybean compared to other crops. I wonder why the authors found relatively small impact as indicated by Line 22, which is one order of magnitude smaller than previous research.
Response: We thank the reviewer pointing this out. We went back to check our calculation, and found out that we misplaced the concentration-response function for the relative yields (RY) for soybean from Mills et al. (2007). For soybean, the RY should be:

$$RY = -0.0116 \times AOT40 + 1.02$$

While we misplaced "1.12" here (see Table 1). After updating our calculations, we estimated that the annual soybean crop yields loss (RYL) reaches 6.51%-9.92% from 2010 to 2017, and much higher in Northeast China, reaching 20% for 8-yr average (e.g., Tianjin, Beijing, and Hebei in Table S6 in the supporting material). We then estimated 1.09-1.84 million metric tons for the ozone-induced soybean yield losses. Avnery et al. (2011a) reported RYL of 21-25% for China, and Zhang et al. (2017) reported 23.4%~30.2% annual soybean yield losses in 2014 in Northeast China. Wang et al. (2022) reported 1.2-1.6 million metric tons per year for the soybean losses from 2014 to 2017 when the same AOT40 metric was used. We now updated all the numbers for the RYL, CPL and economic losses associated with the soybean, as well as all the figures and tables in the main paper and supporting. We genuinely appreciated the reviewer's efforts in finding the error for us.

Reference:

Avnery, S., Mauzerall, D. L., Liu, J. and Horowitz, L. W.: Global crop yield reductions due to surface ozone exposure: 1. Year 2000 crop production losses and economic damage, Atmos. Environ., 45(13), 2284–2296, doi:10.1016/j.atmosenv.2010.11.045, 2011a.

Mills, G., Buse, A., Gimeno, B., Bermejo, V., Holland, M., Emberson, L. and Pleijel, H.: A synthesis of AOT40-based response functions and critical levels of ozone for agricultural and horticultural crops, Atmos. Environ., 41(12), 2630–2643, doi:10.1016/j.atmosenv.2006.11.016, 2007.

Wang, Y., Wild, O., Ashworth, K., Chen, X., Wu, Q., Qi, Y. and Wang, Z.: Reductions in crop yields across China from elevated ozone, Environ. Pollut., 292(September 2021), doi:10.1016/j.envpol.2021.118218, 2022.

L57-60: statement of the key innovation of this study does seem as persuasive, since Line 54-57 indicates that a recent study evaluates effects of ozone on yields of 3 crops for 4 years. The authors do 4 more years of analyses with 1 additional crop (i.e. soybean). Are there new data used or improved model simulation or emission inventories adopted in this research? This novelty statement seems a bit weak. In addition, did previous research not at all examine spatial variations of ozone damages to crop yields? If there are any, they need to be included as literature review here.
Response: We thank the reviewer pointing this out. Our study is innovative in carrying out first long-term temporal and spatial variations of the crop yields loss due to surface ozone in China. Previous studies have been focus on a specific region of China, such as North China Plain (Zhang et al., 2017; Hu et al., 2020; Feng et al., 2020), or Yangtze River Delta only (Wang et al.,

2012). The specific period of 2010-2017 was chosen to cover the emission changes before and after the China's Air Pollution Prevention and Control Action Plan (APPCAP) established in 2013. Previous studies have been reporting the crop yield changes in one year (e.g., Lin et al., 2018; Yi et al., 2018; Feng et al., 2019a,b), or several years after the APPCAP (Zhao et al., 2019; Wang et al., 2022), and our study allows for a comparison for the effectiveness before and after implementation of the APPCAP.

To make the innovation of our study more obvious, we rewrite the sentences from L64-74:
"To date, very few studies have investigated the long-term trends and spatial patterns of ozone impacts on crop production in China. Previous studies have been mainly focus on a specific region of China, such as NCP (Zhang et al., 2017; Hu et al., 2020; Feng et al., 2020), or Yangtze River Delta (Wang et al., 2012). In this study, we focus on the long-term ozone-exposure impact analysis from 2010 to 2017 in China to assess the yield losses of four major crops (wheat,s maize, rice, and soybean) and evaluate their associated economic losses. The specific period of 2010-2017 was chosen to cover the emission changes before and after the APPCAP established in 2013. Previous studies have been reporting the crop yield losses in one year (e.g., Lin et al., 2018; Yi et al., 2018; Feng et al., 2019a,b), or several years after the APPCAP (Zhao et al., 2019; Wang et al., 2022), and our study aims to present a comprehensive analysis of ozone-induce crop yield losses and economic impacts in the agriculture sector before and after the China APPCAP. Such an analysis is expected to provide scientific support to policymakers for their decision making."

Reference:

Feng, Z., Kobayashi, K., Li, P., Xu, Y., Tang, H., Guo, A., Paoletti, E. and Calatayud, V.: Impacts of current ozone pollution on wheat yield in China as estimated with observed ozone, meteorology and day of flowering, Atmos. Environ., 217(March), doi:10.1016/j.atmosenv.2019.116945, 2019a.

Feng, Z., De Marco, A., Anav, A., Gualtieri, M., Sicard, P., Tian, H., Fornasier, F., Tao, F., Guo, A. and Paoletti, E.: Economic losses due to ozone impacts on human health, forest productivity and crop yield across China, Environ. Int., 131(June), doi:10.1016/j.envint.2019.104966, 2019b.

Feng, Z., Hu, T., Tai, A. P. K. and Calatayud, V.: Yield and economic losses in maize caused by ambient ozone in the North China Plain (2014–2017), Sci. Total Environ., 722, 137958, doi:10.1016/j.scitotenv.2020.137958, 2020.

Hu, T., Liu, S., Xu, Y., Feng, Z. and Calatayud, V.: Assessment of O3-induced yield and economic losses for wheat in the North China Plain from 2014 to 2017, China, Environ. Pollut., 258, 113828, doi:10.1016/j.envpol.2019.113828, 2020.

Lin, Y., Jiang, F., Zhao, J., Zhu, G., He, X., Ma, X., Li, S., Sabel, C. E. and Wang, H.: Impacts of O3 on premature mortality and crop yield loss across China, Atmos. Environ., 194(July), 41–47, doi:10.1016/j.atmosenv.2018.09.024, 2018.

Wang, X., Zhang, Q., Zheng, F., Zheng, Q., Yao, F., Chen, Z., Zhang, W., Hou, P., Feng, Z., Song, W., Feng, Z. and Lu, F.: Effects of elevated O3 concentration on winter wheat and rice yields in the Yangtze River Delta, China, Environ. Pollut., 171, 118–125, doi:10.1016/j.envpol.2012.07.028, 2012.

Wang, Y., Wild, O., Ashworth, K., Chen, X., Wu, Q., Qi, Y. and Wang, Z.: Reductions in crop yields across China from elevated ozone, Environ. Pollut., 292(September 2021), doi:10.1016/j.envpol.2021.118218, 2022.

Yi, F., McCarl, B. A., Zhou, X. and Jiang, F.: Damages of surface ozone: Evidence from agricultural sector in China, Environ. Res. Lett., 13(3), doi:10.1088/1748-9326/aaa6d9, 2018.

Zhang, W., Feng, Z., Wang, X., Liu, X. and Hu, E.: Quantification of ozone exposure- and stomatal uptake-yield response relationships for soybean in Northeast China, Sci. Total Environ., 599–600, 710–720, doi:10.1016/j.scitotenv.2017.04.231, 2017.

Zhao, H., Zheng, Y., Zhang, Y. and Li, T.: Evaluating the effects of surface O_3 on three main food crops across China during 2015–2018, Environ. Pollut., 258, 113794, doi:10.1016/j.envpol.2019.113794, 2020.

It is probably also useful to mention the uncertain impacts of climate change on crop yields and increasing future food demand associated with increased population and increased meat demand thus animal feed crops, in the introduction or somewhere in discussion. This will make the evaluation of ozone yield effects and potential mitigation appear to be more urgently relevant to air quality and food security.
Response: We thank the reviewer's insight suggestion. We now rewrite our Discussion, and add the influences of future climate change on crop yields, as well as the different population projections under the SSPs.
Line 258-262:
"Therefore, reducing surface ozone pollution could not only bring the benefits of reducing ozone-related premature deaths, but also bring the benefits of control the global hunger and malnutrition issues, thus helping to reach the Sustainable Development Goal 2 of "Zero Hunger". Meanwhile, Chinese population are projected to continue to increase and peak around 2025 under all the shared socioeconomic pathways (SSPs, Chen et al., 2020), making it more urgent to improve the crop productions by all means."

Line 269-272:
"In our study, we also did not consider the possible climate changes on the crop productions. However, previous studies have demonstrated that temperature increases could significantly reduce the crop productions as well (Asseng et al., 2015; Wiebe et al., 2015; Liu et al., 2016; Zhao et al., 2016, 2017)."

Methods:
Line 83: Model's underestimation of AOT40 seems a bit severe. Is there a way to constrain model results with observations? Does the under-estimation indicate underestimate of ozone concentrations? If this is a modeling issue pointed out before, relevant literature needs to be described? Possible mechanisms need to be addressed in Discussion.
Response: We thank the reviewer's suggestion. Uncertainties in meteorology, emissions, and chemical mechanisms, along with the spatial resolution of chemical transport models, can lead to biases in simulated ozone concentration. These biases are accumulated in concentration metrics, particularly for the threshold-based AOT40 metric. AOT40 metric is accumulated threshold-based metric and so the relationship between ozone concentration and AOT40 is nonlinear (Van Dingenen et al., 2018; Wang et al., 2020), and thus can not be biased corrected using commonly kirgging or Inverse distance weighted (IDW) interpolation methods. Van

Dingenen et al. (2009, 2018) concluded that when averaged at the regional scale, the global transport model simulated crop metrics obtained from the grid boxes reproduces the observations within their standard deviatioins. So considering both reviewer2 and reviewer3' comments, we removed the evaluation for the AOT40 between model and the observation, instead we showed the evaluation for the annual average maximum daily 8-hour average. We revised the sentences from line 77 to line 80:

"We first evaluated the model's performance by comparing the model simulated annual average maximum daily 8-hr average (MDA8) O_3 with the surface observation from 2013 to 2017, which were downloaded from National Environmental Monitoring Center (CNEMC) Network (http://106.37.208.233:20035/). It collects at least 100 million environmental monitoring data from 1497 established air quality monitoring stations annually for national environmental quality assessment. The ozone observation data before 2013 were not available (Lu et al., 2018, 2020). In general, our model captures spatial patterns of the ozone distribution in China (Fig. S6 in Zhang et al., 2021), but overestimates the annual MDA8 O_3 concentration, with mean bias of 5.7 ppbv and normalized mean bias of 13.7% for 5-yr average from 2013 to 2017 (Table 1 in Zhang et al., 2021)."

Results:

1 title 'ozone concentration change' is not precise – it is metric (AOT) value change. Consider revising the title.

Response: We now revise the title to "Temporal and spatial distribution of accumulated ozone change"

Line 141-144 seems to address my previous comment on Introduction but this review of literature has been put in a weird place.

Response: We now move the discussion abouts the ozone increase after year 2014 to the introduction:

"At the same time, however, anthropogenic emission of VOC increased by 11% due to the lack of effective emission controls (Zheng et al., 2018), and surface observations show that the ozone concentration in China still reveals a tendency of increasing (Wang et al., 2020; Li et al., 2018 & 2019a; Lu et al., 2018, 2020). The increasing trend of surface ozone may be partially explained by the decreased titration due to the decreased NO_X emissions especially in megacities (Liu and Wang, 2020a, b; Li et al., 2022), or the decreasing $PM_{2.5}$ which scavenges the radical precursors of ozone (Li et al., 2019a, 2020), though this chemical pathway still exist debates (Tan et al., 2020)."

Reference:

Li, K., Jacob, D. J., Zhang, Q., Liao, H., Bates, K. H. and Shen, L.: Anthropogenic drivers of 2013–2017 trends in summer surface ozone in China, Proc. Natl. Acad. Sci., 116(2), 422–427, doi:10.1073/pnas.1812168116, 2019a.

Li, K., Jacob, D. J., Shen, L., Lu, X., De Smedt, I., and Liao, H.: Increases in surface ozone pollution in China from 2013 to 2019: anthropogenic and meteorological influences, Atmos. Chem. Phys., 20, 11423–11433, https://doi.org/10.5194/acp-20-11423-2020, 2020.

Li, X., Yuan, B., Parrish, D. D., Chen, D., Song, Y., Yang, S., Liu, Z. and Shao, M.: Long-term trend of ozone in southern China reveals future mitigation strategy for air pollution, 269 (118869), 2022.

Liu, Y. and Wang, T.: Worsening urban ozone pollution in China from 2013 to 2017 – Part 1: The complex and varying roles of meteorology. Atmospheric Chemistry and Physics, 20(11), 6305–6321. https://doi.org/10.5194/acp-20-6305-2020, 2020a.

Liu, Y. and Wang, T.: Worsening urban ozone pollution in China from 2013 to 2017 – Part 2: The effects of emission changes and implications for multi-pollutant control. Atmospheric Chemistry and Physics, 20(11), 6323–6337. https://doi.org/10.5194/acp-20-6323-2020, 2020b.

Lu, X., Hong, J., Zhang, L., Cooper, O. R., Schultz, M. G., Xu, X., Wang, T., Gao, M., Zhao, Y. and Zhang, Y.: Severe Surface Ozone Pollution in China: A Global Perspective, Environ. Sci. Technol. Lett., 5(8), 487–494, doi:10.1021/acs.esstlett.8b00366, 2018.

Lu, X., Zhang, L., Wang, X., Gao, M., Li, K., Zhang, Y., Yue, X. and Zhang, Y.: Rapid Increases in Warm-Season Surface Ozone and Resulting Health Impact in China Since 2013, Environ. Sci. Technol. Lett., doi:10.1021/acs.estlett.0c00171, 2020.

Tan, Z., Hofzumahaus, A., Lu, K., Brown, S. S., Holland, F., Huey, L. G., Kiendler-Scharr, A., Li, X., Liu, X., Ma, N., Min, K. E., Rohrer, F., Shao, M., Wahner, A., Wang, Y., Wiedensohler, A., Wu, Y., Wu, Z., Zeng, L., Zhang, Y., and Fuchs, H.: No Evidence for a Significant Impact of Heterogeneous Chemistry on Radical Concentrations in the North China Plain in Summer 2014, Environ. Sci. Technol., 54, 5973–5979, https://doi.org/10.1021/acs.est.0c00525, 2020.

Wang, Y., Gao, W., Wang, S., Song, T., Gong, Z., Ji, D., Wang, L., Liu, Z., Tang, G., Huo, Y., Tian, S., Li, J., Li, M., Yang, Y., Chu, B., Petäjä, T., Kerminen, V. M., He, H., Hao, J., Kulmala, M., Wang, Y. and Zhang, Y.: Contrasting trends of $PM_{2.5}$ and surface-ozone concentrations in China from 2013 to 2017, Natl. Sci. Rev., 7(8), 1331–1339, doi:10.1093/nsr/nwaa032, 2020.

Zheng, B., Tong, D., Li, M., Liu, F., Hong, C., Geng, G., Li, H., Li, X., Peng, L., Qi, J., Yan, L., Zhang, Y., Zhao, H., Zheng, Y., He, K. and Zhang, Q.: Trends in China's anthropogenic emissions since 2010 as the consequence of clean air actions, Atmos. Chem. Phys., 18(19), 14095–14111, doi:10.5194/acp-18-14095-2018, 2018.

Line 145-146: To explain the peak of AOT40 in one specific year, one needs to figure out whether the seasonality of ozone concentrations have changed over time since the growing season likely remain the same across years, correct?
Response: We agree with the reviewer that the growing season for the different crops will be unchanged, at least in our study from 2010 to 2017. The seasonality of ozone concentrations may change though. Meanwhile, for different crops, the growing season will differ too (see Table 1), which makes the direct comparisons very difficult. So in section 3.1, we showed the annual AOT40 changes, instead of seasonal AOT40.

Section 3.2 and 3.3 list many detailed results. I wonder if at the beginning of each paragraph the authors can summarize the findings in one topical sentence. What are the findings that should be noted without getting into all the details? The readers may get very lost with all the details.
Response: We thank the reviewer's suggestion. We now add one topical sentence in each from section 3.2 to 3.4:
Line 158:
"The accumulated AOT40 values vary among the four crops, mainly determined by the seasonality of ozone concentrations."

Line 186:
"From equation 3, we expect that the spatial distribution of CPL among the four crops would be different from their RYLs."

Line 217-218: results of this research is much much smaller than this previous research.
Response: See our response to the comments about Line 48-54.

Discussion:
It appears to me that Line 250-279 are still about results, although some comparisons with earlier research has been added.
Line 280-end appears to be actually like a real 'Discussion' that really expands the findings of the research. There are not very clear messages to policymaking regarding ozone control in which provinces should be prioritized. Consider improving the Discussion. More details could be provided regarding how to address ozone pollution in prioritized regions (i.e. high losses).
Response: We appreciate the reviewer's comment about the discussion. We feel these two questions are related, so we address them here together. We now rewrite the discussion. In the new Discussion section, we talked about the decreasing trend of ozone-induced crop yields losses in China after 2013, the future climate and population changes on crops, and also the uncertainties for our study originating from the model, the emission inventories and the concentration-response function we used. We also rewrote the Results and Summary section to show the results only.
"4 Discussions

Surface ozone emerged as an important environmental issue in China, and were shown increasing trend in major megacities for the past few years using both modelling and observation data (Lu et al., 2018, 2019; 2020; Li et als., 2020; Liu and Wang, 2020a,b; Ni et al., 2018; Wang et al., 2020), though strict clean air regulations have been implemented after 2013. Exposure to high concentrations of surface ozone not only poses threat to human health, but also cause damages to crop. Our study presented a comprehensive analysis on the impact of surface ozone exposure on four major crop production loss in China, including wheat, rice (double early and late rice, single rice), maize (north maize and south maize), and soybean. Unlike the surface ozone trend, we showed that the national crop yields for major crops in China usually peaks in 2014 or 2015, shortly after the strict clean air regulations after 2013. The decreasing trend of crop yield losses associated with surface ozone exposure was mainly explained by the fact that the surface ozone in China were increasing in urban areas, while decreasing in the rural areas (Li et al., 2022), where the major crops are planted. Nonetheless, the relatively higher ozone, especially compared with developed countries, such as United States and Japan (Lu et al., 2018), are still posing great threats to crop productions in China. Combing the annual crop production from the Statistical Yearbook of China, we estimated that the surface ozone in China could cause an average of 26.42 million metric tons losses (Mt) of wheat production from 2010 to 2017. These losses are even comparable to the annual average wheat production during the same period in Paris, which is the fifth largest wheat production in the world (http://www.fao.org/faostat/en/#data/QC, accessed December 12, 2021). We also estimated that the surface ozone exposure could cause 18.58 Mt losses of rice production in China, comparable to the annual rice production in Philippines, the world's 8th largest rice production. Transferring to economic values, we estimated the surface ozone exposure could cost more than 20 billion $ losses, representing more than 0.20% of annual average Gross Domestic Product (GDP) in

China from 2010 to 2017. The latest edition of the State of Food Security and Nutrition in the World estimated that between 720 and 811 million people in the world faced hunger in 2020, with 161 million increasing compared with 2019, and nearly 2.37 billion people did not have access to adequate food, with no regions spared (FAO, 2021). Therefore, reducing surface ozone pollution could not only bring the benefits of reducing ozone-related premature deaths, but also bring the benefits of control the global hunger and malnutrition issues, thus helping to reach the Sustainable Development Goal 2 of "Zero Hunger". Meanwhile, Chinese population are projected to continue to increase and peak around 2025 under all the shared socioeconomic pathways (SSPs, Chen et al., 2020), making it more urgent to improve the crop productions by all means.

Uncertainties exist in the design of our study, including the coarse resolution of the global transport model we used, the regional emission inventories, as we as the concentration-response functions. From the model evaluation, we learnt that our model tends to overestimate the annual MDA8 O_3 concentration in China. However, through sensitivity experiences, Wang et al. (2022) showed that model biases in ozone were likely to have a relatively small impact on estimated production losses. The uncertainties from the changes in growing seasons, and the concentration-response functions tend to have larger effects. We propose that further studies, using high-resolution bias-corrected ozone concentration data and region-specific response functions, need to be carried out to quantify the negative effects of surface ozone on crops. In our study, we also did not consider the possible climate changes on the crop productions. However, previous studies have demonstrated that temperature increases could significantly reduce the crop productions as well (Asseng et al., 2015; Wiebe et al., 2015; Liu et al., 2016; Zhao et al., 2016, 2017). Despite these limitations and uncertainties, our study strives to estimate the long-term negative effects from surface ozone exposure in China before and after the clean air action in China. These estimations could provide the government and policy-makers useful references to be taken into account of the detrimental effects of ozone exposure on crop productions in China when making regional-specific ozone control policies."

Grammar issues need to be fixed, to name a few, line 20 'in 2017'; Line 73 'outside of China' instead of 'outside China'

Response: We appreciate the reviewer's comments. We changed the above issues following the reviewer's suggestions.

We spent quite an effort to improve our writing when preparing for the revisions from all the coauthors. We also seek external help from senior researcher Dr. Russell Harwood (russell.harwood@duke.edu) from Duke University for advice. We believe our writing has been greatly improved.

Tables and Figures:

Table 1 seems to be methods and from previous research, instead of actual research design or results.

Response: we agree with the reviewer that the values from Table 1 are from previous research. We put it here to help the reviewers recognize the growing seasons and spatial distributions of major crops in Chinese provinces. Checking out previous studies (Lin et al., 2018; Wang et al., 2022), we prefer to keep Table 1 in the main paper. However, we changed the title to the following:

“Table 1: Overview of the concentration-response function for the relative yields (RY) for ozone exposure on different crops”

Figure 3 consider putting the names of corresponding crops next to the (a) (b) (c) (d)...
Response: Thanks for the suggestion. We now add the corresponding crops next to the (a) (b) (c) (d).

Figure 4 For some crops, the losses peak at 2014 while for others the losses peak at 2015.
Response: The reviewer is right that the yield losses for the different crops vary across years, which are caused by the different change patterns for seasonal ozone.

Figure 5 the caption needs to describe panels a) and b). Do you simply group the provinces based on the magnitude of values?
Response: Fig. 5 a) & b) shows the wheat production loss by magnitude for all the province in China. As also pointed out by Reviewer 2, we agree that there are too many bars for both Figs 5 & 6. So we revised these two plots to show only the top 5 provinces with the largest crop loss. The province-level results are kept in the Tables S7-S12 in the supporting material.