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.

The research presented in the paper aims to quantify the impacts of atmospheric oxidizing capacity (AOC) on the secondary organic aerosols (SOA) as well as ozone in North China. A specific version of WRF-Chem developed by the authors were employed to simulate the role of AOC during a winter severe haze event. I found the results from this work are critically important in understanding and evaluating the Air Pollution Control Action Plan currently being implemented in China. The paper is well organized and written, and the topic is highly relevant with the scope of ACP. Hence, I recommend acceptance of the manuscript after the following minor comments are addressed.

Comment 1. The simulated AOC influence on SOA is convincing, but one question unclear to me is what cause the AOC increase in observations? Is it due to the reduced aerosol concentration and elevated near-surface solar radiation after the pollution control plan?
Response: We have clarified in Section 3.1: "*The reason for the AOC or O_3 increase since 2013 still remains elusive. Li et al. (2018) have proposed that the O_3 increase in China since 2013 is associated with the decreased removal efficiency of HO_x (OH + peroxy) on aerosol surfaces caused by the reduced aerosol concentrations since the implementation of APPCAP. However, further studies need to be conducted to evaluate the O_3 contribution of the photolysis change caused by the aerosol-radiation interaction and aerosol-cloud interaction induced by decreasing aerosols in China.*" in Lines 191-197.

Li, K., Jacob, D. J., Liao, H., Shen, L., Zhang, Q. and Bates, K. H.: Anthropogenic drivers of 2013-2017 trends in summer surface ozone in China, Proc. Natl. Acad. Sci. U.S.A., 17, 201812168–6, doi:10.1073/pnas.1812168116, 2018.

Comment 2. The increase in the ratio of OC to EC has significant implication for atmospheric radiation and thermodynamical profiles. It may increase both aerosol scattering and absorption simultaneously. The former is related with near-surface solar radiation as mentioned above, while the latter further regulates the atmospheric stability. If the authors have related model output from the case study, it would be interesting to examine those changes in the atmosphere.

Response: We have clarified in Section 3.3.1: "*It is worth noting that the increase in OC/EC ratio potentially influences atmospheric radiation and thermodynamical profiles, through enhancing aerosol scattering and absorption simultaneously (Wang et al., 2013). When the photolysis frequencies are reduced by 30% in the SEN3 experiment, compared to the REF, the downward shortwave radiation is reduced by 1.2 W* m^{-2} *on average in BTH, and the surface temperature is decreased by around 0.016* ^{o}*C during daytime. Effects of the AOC change on the temperature profile is not significant, and the daytime temperature decrease in the SEN3 experiment is less than 0.005* ^{o}*C within 1 km height from surface.*" in Lines 297-304.

Comment 3. L126-128, good to see a FDDA method is used in the model simulations. Can the authors be specific about what meteorological fields are constrained by what observations?
Response: We have revised the sentence to make it clearer in the text: "*Specifically, the surface and upper air observational wind fields from China Meteorological Administration (CMA) during the study period are assimilated using the four-dimensional data assimilation (FDDA) method to better simulate meteorological fields.*" in Lines 131-134.

Comment 4. L169, why not from 2013 to 2017 like Fig. 3a? Is it due to the data availability?
Response: Yes, the data after 2015 are not available.

Comment 5. Fig. 8&9, the model reasonably well reproduces the temporal evolutions of the major pollutants, both gaseous and particulate. The authors should mention what is the temporal resolution of the emission data used in this study and if it provides the data during the exact same time period.
Response: We have clarified in Section 2.1: "*The monthly average anthropogenic emission inventory is developed by Zhang et al. (2009) and Li et al. (2017c) with the base year of 2013, including agriculture, industry, power generation, residential, and transportation sources. The temporal resolution of emissions used in simulations is 1 hour, and the temporal allocation for different sources follows those in Zhang et al. (2009).*" in Lines 139-144.

Comment 6. L241-242, why do the wind biases cause an underestimation of EC only, not POA?
Response: We have revised the sentence as: "*Although the IOA and r for the simulated EC concentration reach 0.92 and 0.90, respectively, the model considerably underestimates the EC concentration against measurements on October 6 and 7, which is likely caused by the variation in anthropogenic emissions.*" in Lines 267-270.

Comment 7. Figure 6, why the circles in the map have different sizes?

Response: We have clarified in the caption of Figure 1: "... *the size of the circles represents the number of sites in each city.*" in Lines 733-734 and 681-682.