

Referee #1:

The authors used regional chemical transport model to describe the evolution of ozone formation in an urban city. They studied the different characteristic of the ozone formation before, during and after tropical cycle passing by, and also explained the possible cause for the high ozone at the urban city even when strict air pollution controls were carried out. In general, the paper is not well summarized, but the explanations were also poor. Time should also be spent to describe their methodology on the emissions, and the model setup. Please see my comments below. Also the authors need to keep consistent for the tense used in the main manuscript. The authors keep switching from present to past tense in the whole paper.

Reply: We thank the reviewer for the constructive comments and suggestions. We have carefully revised the manuscript based on the reviewer's comments. Please see the specific responses shown below.

Specific comments:

1. line 25: define O₃.

Reply: Revised as suggested.

2. line 28-29: explain what is the new mechanism. Otherwise, rewrite this sentence.

Reply: Original sentence "A unique mechanism was found to modulate the high ozone episodic event" has been rewritten as "High O₃ episodes were characterized" in line 28.

3. line 30: change "are" to "were";

Reply: Revised as suggested.

4. line 32: change "intensify" to "intensified";

Reply: Revised as suggested.

5. line 52: define O₃ and CO; put reference for line 52-53

Reply: Revised as suggested.

6. line 55-58: surface ozone is not considered as climate forcer, but actually the tropospheric ozone.

Please modify.

Reply: Original phrase “but also has warming effects as a short-lived climate forcer (Monks et al., 2015)” has been removed.

7. line 75-76: rewrite the sentence.

Reply: Original sentence has been rewritten as “In the Yangtze River Delta (YRD) region of China, high O₃ concentrations are associated with the pollutant transport and diffusion from surrounding areas (Gao et al., 2016; Jiang et al., 2012).” in lines 69-71.

8. line 81: suggest to change the reference to Lin et al., 2012, 2015.

Reply: Revised as suggested.

9. Line 101: define WRF-Chem as it was first shown here;

Reply: Revised as suggested.

10. Line 111-113: I was confused by what data was actually used here, and what is the purpose.

Reply: The data here indicates the model outputs. The original sentences “the hourly data during August 24–September 6, corresponding to the official air pollution control measures implemented during the G20 summit, were used in the following analysis” have been revised as “Hourly model outputs for 24 August to 06 September were used in the analysis.” in lines 106-107.

11. Line 115-116: Does the U.S. Geological Survey database includes the terrain soil properties, and albedo info for China? Please clarify. Also, please detail the interpolation process.

Reply: Right, U.S. Geological Survey database includes the terrain soil properties and albedo info for China. We also did double check of the WRF Preprocessing System (WPS) output (from geogrid.exe). The interpolation method was based on the default method documented in the WRF

Preprocessing System (GEOGRID.TBL). For example, for albedo, the interpolation method was based on the combination “four_pt+average_4pt+average_16pt+search.” Individually, these four interpolation methods correspond to “four-point bi-linear interpolation,” “simple four-point average interpolation,” “simple sixteen-point average interpolation,” and “breadth-first search interpolation.” In this study, selection of interpolation methods began with the first-mentioned method (i.e., four-point bi-linear interpolation) and progressed until an appropriate method was identified. The primary limitation in this process was data availability. Additional details regarding the interpolation method are available at <http://www2.mmm.ucar.edu/wrf/users>. The revisions have been reflected in the revised manuscript of lines 114-123.

12. Line 120-122: put reference for the FNL dataset.

Reply: Reference has been added.

13. Line 123-125: describe the simulation period & setup for the MOZART4 simulation which was used to provide the BCs and ICs for the WRF-Chem runs. Does the dynamical BCs were adopted from MOZART4, or only profile data used?

Reply: Dynamical BCs were adopted from the global simulation results of MOZART4. These result data was downloaded from the website: <http://www.acom.ucar.edu/wrf-chem/mozart.shtml> and interpolated (downscaled) into the model-ready data through a tool program named “mozbc” in the WRF-Chem model. Further detail can be seen in the official user guide (<https://ruc.noaa.gov/wrf/wrf-chem/>).

To make it more clear, original statements “the chemical boundary and initial conditions were interpolated from the results of the global Model for Ozone and Related Chemical Tracers Version 4 (MOZART4) (Emmons et al.,2010).” have been revised as “The chemical initial and boundary conditions were dynamically downscaled from the model for ozone and related chemical

tracers, version 4 (MOZART4) (Emmons et al., 2010) simulation results; the relevant data are available at <https://www.acom.ucar.edu/wrf-chem/mozart.shtml> in lines 129-132.

14. Line 129-130: which year's emission inventory from MEIC was used in this study?

Reply: The 2016 Multiresolution Emission Inventory for China (MEIC, $0.25^\circ \times 0.25^\circ$; <http://www.meicmodel.org/>) was used.

15. Line 131-133: the authors should describe in detail how they get the finer emission inventories, and how did the O₃ precursors look like. Suggest add a table to show the results.

Reply: The finer emissions in YRD have been discussed in detail by Huang et al. (2011), Li et al., (2011) and Liu et al. (2018). The spatial distributions and tables have been shown in these three papers. Therefore, we briefly discuss the emission inventory shown below, which is also reflected in the revised manuscript.

Sentences “Inventories of finer anthropogenic emissions for the YRD region over the year of 2014 were compiled based on the bottom-up method by Shanghai Academy of Environmental Sciences. These inventories have been documented in detail in previous studies (Huang et al., 2011; Li et al., 2011; Liu et al., 2018). Thus, only brief discussions of these inventories are presented herein. The fine emission inventories include major sectors such as large point sources, industrial sources, mobile sources, and residential sources. The anthropogenic emissions over the YRD region are mainly located over the industrial and urban areas along the Yangtze River as well as over Hangzhou Bay.” have been added in lines 138-145.

Reference:

Huang, C., Chen, C. H., Li, L., Cheng, Z., Wang, H. L., Huang, H. Y., Streets, D. G., Wang, Y. J., Zhang, G. F. and

Chen, Y. R.: Emission inventory of anthropogenic air pollutants and VOC species in the Yangtze River Delta region, China, *Atmos. Chem. Phys.*, doi:10.5194/acp-11-4105-2011, 2011.

Li, L., Chen, C. H., Fu, J. S., Huang, C., Streets, D. G., Huang, H. Y., Zhang, G. F., Wang, Y. J., Jang, C. J., Wang, H. L., Chen, Y. R. and Fu, J. M.: Air quality and emissions in the Yangtze River Delta, China, *Atmos. Chem. Phys.*, doi:10.5194/acp-11-1621-2011, 2011.

Liu, Y., Li, L., An, J., Huang, L., Yan, R., Huang, C., Wang, H., Wang, Q., Wang, M. and Zhang, W.: Estimation of biogenic VOC emissions and its impact on ozone formation over the Yangtze River Delta region, China, *Atmos. Environ.*, doi:10.1016/j.atmosenv.2018.05.027, 2018.

16. Line 136-137: for the biogenic emissions from MEGAN, describe the online or the offline version was used for this study.

Reply: The offline version of MEGAN was used in this study. Original sentence has been revised as “biogenic emissions were generated off-line using the Model of Emission of Gases and Aerosols from Nature (Guenther et al., 2006)” in line 149-150.

17. Line 152: suggest to change “model result” to “model results”

Reply: Revised as suggested.

18. Line 158-159: suggest to change to “the meteorological parameters were also evaluated with the observational data, including”

Reply: Revised as suggested.

19. Line 163-164: put reference for the LiDAR data.

Reply: Reference has been added.

Reference:

Su, W., Liu, C., Hu, Q., Fan, G., Xie, Z., Huang, X., Zhang, T., Chen, Z., Dong, Y., Ji, X., Liu, H., Wang, Z., Liu, J., 2017. Characterization of ozone in the lower troposphere during the 2016 G20 conference in Hangzhou. *Sci. Rep.* 7, 17368. doi:10.1038/s41598-017-17646-x

20. Line 167-168: not a complete sentence.

Reply: Original sentence has been revised as “The DIAL technique can be used to measure O₃ concentrations above or near a specific location (Browell, 1989)” in lines 184-185.

21. In Fig. 2: describe the figures a, b and c, d, as “scatter plots for the MFB and MFE... scatter plots for daily observed and modeled O₃ (c) and NO₂ (d).

Reply: Revised as suggested.

22. Line 179: change “evaluate” to “evaluated”

Reply: Revised as suggested.

23. Line 181: change to “agreed”

Reply: Revised as suggested.

24. Line 182: add “as” in front of shown in fig 2.

Reply: Revised as suggested.

25. Line 183: Fig 2c has nothing to do with MFB and MFE. Consider to remove. The same as line 185

Reply: Revised as suggested.

26. Fig 3. Describe the observational data used for evaluating the model performance in Hangzhou.

Reply: The observational data source including the air quality data and meteorological data has been added in the section 2.4

27. In fig 6, in the captions, please detail the heights in each plot. The Y axis on the plot e-h is NO₂, which is different with the NO_x listed in the caption. Add the units of O₃ for plot a-d in the caption.

Reply: Revised as suggested. “NO_x” has been corrected as “NO₂”.

28. Line 228: “The O₃ concentrations increased in the daytime” I did not understand how the authors made this conclusion from Fig. 6.

Reply: The original sentence was used to express high ozone in the daytime compared to nighttime.

To avoid confusion, we have removed this sentence.

29. Line 230-245: remove the hyphen between numbers and “hPa”

Reply: Revised as suggested.

30. Line 244-245: “This result is in contrast to the O₃ variation found in the vertical layers.” Put reference for this sentence. Also explain why the differences are.

Reply: The reference and explanation has been added. The following information has been added in the revised manuscript (lines 280-284).

The vertical distributions of O₃ and NO₂ were consistent with those recorded in a previous field study (Xing et al., 2017), implying that the greater ozone concentrations at higher altitudes in relation to the concentrations at the lower level (i.e., surface) probably contributed to NO titration (i.e., O₃ + NO → NO₂ + O₂) at the low altitude.

Reference:

Xing, C., Liu, C., Wang, S., Lok Chan, K., Gao, Y., Huang, X., Su, W., Zhang, C., Dong, Y., Fan, G., Zhang, T., Chen, Z., Hu, Q., Su, H., Xie, Z., Liu, J., 2017. Observations of the vertical distributions of summertime atmospheric pollutants and the corresponding ozone production in Shanghai, China. *Atmos. Chem. Phys.* 17, 14275–14289. doi:10.5194/acp-17-14275-2017

31. Line 345-347: this study is not representative of major urban ozone pollutions.

Reply: We have added the specific event of “during a tropical cyclone event.” to emphasize the event is tropical cyclone related instead of regular major urban ozone pollution.

32. In the supplementary: Page 1: keep the title consistent with main manuscript

Reply: Revised as suggested.