

## Review of “Dominant Patterns of Summer Ozone Pollution in Eastern China and Associated Atmospheric Circulations”

The authors have greatly improved the manuscript responding to the two reviewers' comments. I believe this paper is suitable for publication after minor revisions. My largest minor points are:

**Line 28-30:** Include the boxed regions shown on Figure 3a,c on the other figures of Eastern China ozone (e.g., Figure 1, 4,7,8) to assist the reader throughout the manuscript. Then here when you list the location of these regions the authors can reference Figure 1b.

**Line 111:** Do you think the high levels of MDA8 around the large cities has to do with aged pollutant transport in the cities, which may be related to lower O<sub>3</sub> in the cities due to NO<sub>x</sub> titration but outside of the cities the air was in a different NO<sub>x</sub> regime and O<sub>3</sub> increased? This idea has been largely absent from this paper, but I believe it is worth discussing.

**Line 116:** Severe O<sub>3</sub> pollution is mentioned a few times in the paper but “severe” is not defined as a threshold. What do the authors mean by this? Is it anything above “Moderately polluted”?

**Line 139:** The authors focus the discussion of PAT2 on NC and YRD, with the occasional mention to PRD (e.g., line 207-208). Often there are places where the comment applies to both YRD and PRD (e.g., Lines 146, 181-202) and could be included. Is there a reason why not to include it in the discussion of PAT2?

**Lines 223-251:** I am not convinced by the discussion of Figures 10 and 11 as this is one year being compared to a really small sample size of a four-year average which includes that same one year. It is the nature of the availability of the data that the authors choose not to extend their analysis further back. I think the paper can stand alone without these two additional figures and discussion. This could be revisited after more time has passed in a later publication.

### **Minor and technical comments:**

Line 22: Start off the first sentence with something like “High levels of ozone occur both in the stratosphere and at the ground level”. Otherwise ozone occurs throughout the troposphere, just not always at unhealthy concentrations.

Line 34: I do not understand the significance of the greater ozone trend on the highest mountain in NC. This indicates to me that the background ozone in the free troposphere in the region is possibly increasing. Is this what the authors mean? Please clarify the significance of this statement.

Line 44: I believe the Li et al. paper (note, add the period after 'al' in this sentence. It is missing. Check all references for this) uses the GEOS-Chem CTM, not the GEOS CTM. These are different models.

Line 57: Can the authors provide a summary sentence at the end of this paragraph linking all these studies together?

Line 58-59: The authors claim that Wang et al. (2017) claim the study uses ozone data from prior to 2010. How can the reader then assume that the 7 referenced studies in the paragraph above with publication dates prior to 2019 are using recent enough ozone data to that the authors can use these papers to make their claims?

Line 62: I know I asked how your study is different to the Zhao and Wang (2017) paper, but stating "Actually, in our study, we found the ...." comes out of nowhere compared to the rest of your introduction. Please modify this sentence to be less aggressive and more like, "In this study, we built upon the previous literature analyzing ozone and meteorological influences thanks to the availability of more ozone observations by the chinese government since 2015, providing us more information to analyze then available in these earlier studies, e.g., Ziao and Wang (2017)."

Line 73: What threshold was used to unify the sites? For example, did some sites move location but still considered as one time series?

Line 80: Thank you for adding this detail. However, I am not used to this type of notation; is there a reason some left brackets are curved ( and not [ ?

Line 82: Can you provide a link either here in the text or at the end of the paper in a "Data Availability" section to where you got the ERA-Interim data.

Line 83: Remove at to read "temperature from surface to 100 hPa"

Line 86,89-90: I am still confused by this description of reanalysis timesteps to Beijing time. How many 6-hourly reanalysis timestamps are used in the daytime data analysis? Why are there different time period for the 3-hourly data than 6 hourly data? Can you use the same time period but just more 3-hourly data? 00 am to 00pm UTC does not make sense. I think you mean 00 UTC to 12 UTC which would mean you have 3 6-hourly timesteps (00, 06, 12 UTC). The am and pm should also be removed from the 21 UTC to 09 UTC. And this means you have 5 3-hourly timesteps (21, 00, 03, 06, 09 UTC). Why is this offset 3 hours from the 6-hourly timesteps (could have done 00,03,06,09, 12 UTC)?

Line 94: remove 'ly' from relatively

Line 104: I suggest changing this sentence to "...was mostly lower than 100 ug/m<sup>3</sup>, and lower than the O<sub>3</sub> pollution in North China and in the Huanghuai area (NCH, about 31-41N, 110-

120E)". This modifies the second half of the sentence as well as adding in the box region for the NCH (which I guessed from Figure 3).

Line 112: are cities large and small based on population or area-covered?

Line 115: Could highlight that this threshold is matching the list now given in line 80-81; e.g., change to ....the threshold of "heavily O3 pollution" in China...

Line 118: Are these cities with large populations "Megacities"?

Line 119: How often was the MDA8 value nearly above 100 ug/m3? Are you trying to say the ozone was hardly below 100 ug/m3 on any day in the time series?

Line 122: What does "exceeded the health threshold" in reference to? Is that "Good" and above?

Line 127: Change reference to (Figure 2a,b)

Line 141: There looks to be extra spacing in front of -1x

Line 142: Change showed to shows. There are other places where the authors switch back and forth between verb tenses (e.g., Line 154, 159).

Line 145: add (Fig 4a,b) after "respectively".

Line 149: change recent four years to "the four years of study" since this becomes less true after publication.

Line 150: What does "were reasonably supposed to be relatively stable on the daily time-scale" mean. I think change to "Despite the economic productions and human activities steadily increasing from 2015 to 2018 in Eastern China, we assume the emissions of ozone precursors to be relatively stable on the daily time-scale".

Line 154-156: I do not feel this "For example, " sentence is necessary.

Line 158: so this is stagnation and as such there is the buildup of pollutants too without removal from weather systems passing by. I do not think that idea has been discussed.

Line 159: Start sentence with "In Figure 5a, there are negative ..."

Line 163: Change to "(EAT, Table 1)"

Line 166: This final part might be a bit of a stretch.

Line 184: In the author's comments to my first review, they explain to me why they choose different pressure levels for Figure 5a and 6a, but please include the reasoning in the paper.

Line 186: It is really difficult to find Chukchi Peninsula on the map given the country lines are in grey. Can you include lat/lon of the region you mean because I think the peninsula is mostly under negative Z500.

Line 188: Similarly, I would argue that it was limited to the east of Korea so again add coordinates to ensure your reader is looking where you want them to be looking.

Line 194: Remove the word obvious.

Line 204: Change "the past four years" to "these past four years" as this will change after publication.

Line 217: Could include a reference to Fig 8.

The following are the reasons why I do not think Figures 10 and 11 add to the manuscript:

Line 223: change to "were generally negative". I think there is a mix of positive and negative in the YRD in Figure 7b, not strictly positive as is written.

Line 227: Again, I see a ridge over Chukchi Peninsula, not a trough, so include coordinates of where you want the reader to be looking.

Line 229: Both Figure 10 and 11 could have the same purple arrows to identify how the authors would calculate the WPSH as in Figures 5 and 6. Again, authors could include coordinates or a box region as in Figures 5 and 6 to indicate the location of EAT and WPSH.

Line 231: I disagree with the authors that more low to mid-level clouds formed as it looks to me that the box straddles the zero line and that instead of a decrease in solar radiation reaching the ground in NC I see positive colors in that box too in Figure 10d.

Line 236: What do the authors mean by "south of YRD"? Do they mean outside of the box or the southern portion of the YRD? Does that mean PRD?

Lines 225-237: There are no significant differences near the NC or YRD in any of the four panels in Figure 10.

Line 238: I do not like how the sentence starts with "--+--". Can the authors at least put "The" prior to the symbols? Is this the same as an OMEGA block and could be written as such instead of --+-- ?

Line 243: I do not see an anomalous anticyclone over the NCH in Figure 11a, but more on the border with cyclonic flow to the southwest and anticyclone to the east, and as the authors describe later in reference to the water vapor flux, the NCH is in a region of anomalous divergent flow.

Line 244: When the authors say “it was difficult to form cloud” the NCH straddles the zero line and shows a mix of both positive and negative SSR so how can they say “more solar radiation directly reach the ground (Figure 11d)”?

Line 247: Out of nowhere the authors mention “signals of global warming”. Such bold statements in a manuscript, which depend on figures in the supplemental material, should not be made.

Overall the Discussion is fine.

Line 254: Add a reference (e.g. Li et al., 2018) to the end of the opening sentence, possibly bringing over the point made at the end of the discussion on line 281 “At present, the fine PM decreased in the summers in eastern China....”.

Line 264: the increased SAT and thus decreased cold air advection from the north a) seems backwards (less cold air advection would likely lead to increased SAT at lower latitudes) and b) the negative Z500 to the west with flow from south and southwest likely brought warmer temperatures from the southern latitudes into the region.

Line 270: “...daily emission data were difficult to be acquired” implies the authors have acquired such data. Is that true or are these data difficult to acquire?

Line 273: remove the comma before (2019).

Line 275: How were the “domestic anthropogenic emissions alone would have led to ozone decreases” determined by the Lu et al. study?

Line 277: Is “were still unclear” in reference to your work presented here or in reference to the Lu et al. study?

Figure comments:

Figure 2: Can NC, NCH, YRD, and PRD be added to the Figure caption in a similar fashion to how it was added to the Comments to the Reviewer (Page 47). Also, could add a reference to Figure S2 in the caption to remind readers to look there for the locations of these cities.

Figure 3: Add to Figure 3 caption what the dashed lines in panels b and d represent. I assume horizontal are the standard deviation and the vertical separate the years.

Figure 5, 6, 10, 11: The units for water vapor flux are written as  $\text{kg}\cdot\text{m}/(\text{kg}\cdot\text{s})$  which is a bit odd. I strongly encourage the authors to use negative values to indicate denominators in units throughout the paper. This would change these units to  $\text{kg m kg}^{-1} \text{s}^{-1}$  which then leads me to my next question whether these are the correct units. In its current form are the kg's representing different things (dry air vs moisture?)

Figure 7: It is difficult to see the crosses when the O3 anomaly is less than -25 ppb (the dark blue color). Can that be adjusted? Or maybe have white crosses instead? Also the y-axis minor tick marks are an odd spacing compared to the major 5 degree labelled tick marks. Can these minor tick marks be changed to maybe every 1 degree?

Figure 9: Are the variations in reference to an average for all available sites in the NC and the YRD regions? If so, please add this level of detail to the Figure 9 caption.