Response: Impacts of tropical cyclone-heatwave compound events on surface ozone in eastern China: Comparison between the Yangtze River and Pearl River Deltas

Cuini Qi [1], Pinya Wang [1, *], Yang Yang [1, *], Huimin Li [1], Hui Zhang [1], Lili Ren [2], Xipeng Jin [1], Chenchao Zhan [3], Jianping Tang [4], Hong Liao [1]

Dear Editor,

We would like to submit our revised manuscript entitled "**Impacts of tropical cyclone-heatwave compound events on surface ozone in eastern China: Comparison between the Yangtze River and Pearl River Deltas**" to ***Atmospheric Chemistry and Physics.***

On behalf of my co-authors, we thank you for handling the peer review of our manuscript. We appreciate your time and efforts as well as those of the two referees for the careful reviews and constructive comments that have helped improve the quality and readability of the manuscript. We have carefully revised our manuscript to address the comments accordingly. Below are the point-to-point responses to the review comments.

Kind regards,

Key:

Black: Reviewer's comments

Blue: Author's responses

Reviewer #3:

General Comments: This manuscript presents a study case of the effects that a combination of heatwave conditions and a tropical cyclone have on the presence of surface ozone over two river deltas in China. The observational dataset includes a good number of observation sites for temperature, as well as relevant typhoon data publicly available. As for the reanalysis dataset, the authors use ozone data from ChinaHighO_3 dataset and ERA5 data for the meteorological conditions, both of which are widely used in the community. The methodology used to identify extreme events is appropriate as well as the presentation of the results, although the understanding of some figures could be improved by changing the colors used. The authors compared the results obtained with those already presented in the literature and include information about the meteorological situation in the episodes they study that justify their findings. However, the authors should revise the document as some sentences are difficult to read and the clarity of some figures could be improved (see some examples in the "technical corrections" section below).

As for the literature, the authors made a comprehensive revision of previous studies connected to the relationship between heatwaves and ozone, as well as between tropical cyclones and ozone. Articles dealing with the compound effect of both meteorological events on surface ozone are not numerous, but the authors cited the most relevant ones. In that sense, the authors are trying to fill a gap in our knowledge and that is relevant for the scientific community, policy makers and for the public in general, especially for those living in areas prone to high levels of pollution and tropical cyclones with heatwave episodes, especially considering future projections under climate change scenarios.

The findings presented in this study are relevant and important for the community as mentioned before. Taking into this brief assessment, I recommend the manuscript to be published after minor corrections.

Reply: We thank the reviewer for the constructive comments and suggestions, which are very helpful for improving the clarity and reliability of the manuscript. We have

revised some sentences for better readability and enhanced the clarity of some figures. Please see our point-by-point responses to your comments below.

Major comments:

In the discussion of the spatial distribution of surface MDA8 ozone concentration in section 4, could the authors discuss why the ozone concentration decreases over Hainan islands and the north part of the SECC during TC-HDs events?

Reply: Thanks for your constructive and helpful suggestions. "Particularly, for the decrease MDA8 ozone in Hainan islands, we can see that during TC-HDs, Hainan islands is covered by decreased T2m, increased RH, reduced SSRD, and increased TCC (Figs. 7a-d), along with negative H500 and MSLP anomalies (Figs. 7e&f). Such meteorological conditions in Hainan islands may suppress the chemical production of ozone and the oceanic winds may clean the air (Fig. 7e). On the other hand, for the north part of SECC, the circulation anomalies favor strengthened southeastern moisture flow and enhance the convergence of water vapor flux there (Fig. S3), which can lead to increased relative humidity (Fig.7b). The local higher temperature (Fig. 7a) and humid conditions may favor convection activities (Wang et al., 2019b), characterized increased cloud cover (Fig. 7d) and decreased surface solar radiation (Fig. 7c). These meteorological conditions can inhibit the local ozone production and cause a lower ozone concentration in north part of the SECC during TC-HDs."

Accordingly, we have added explanations on the decreased ozone concentrations over Hainan islands and the north part of the SECC during TC-HDs events in the updated manuscript **(Lines 305-315)**.

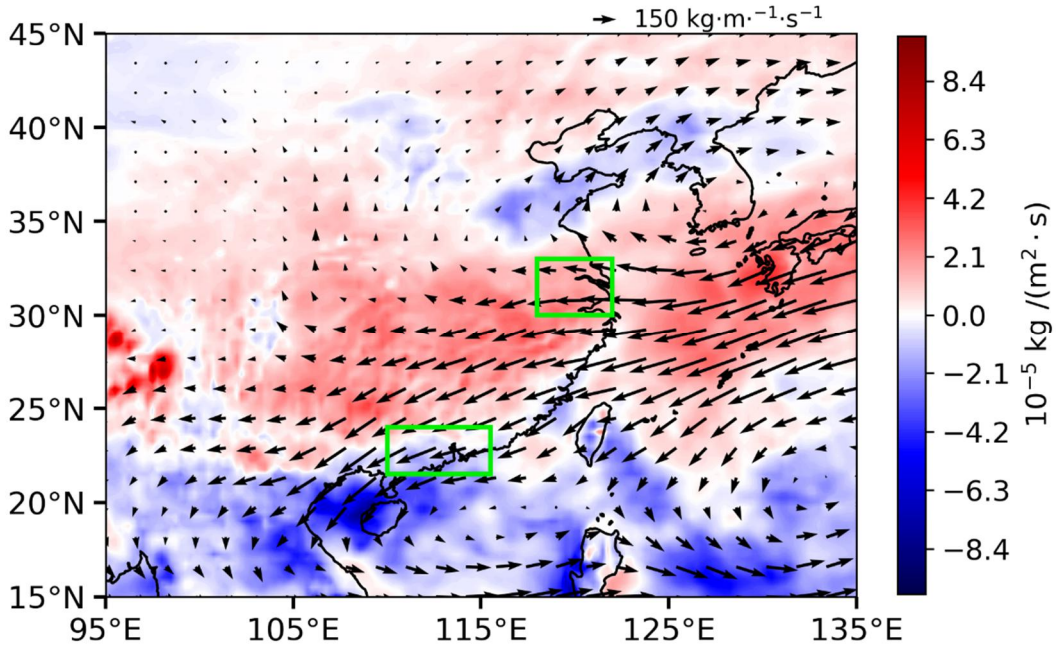

Figure S3. The vertically integrated water vapor transport flux (vectors, unit: kg m^{-1} s^{-1}) and divergence anomalies (shading areas, unit: 10^{-5} kg m^{-2} s^{-1}) in reanalysis datasets ERA5 during TC-HDs compared to the summer climatology. YRD and PRD regions are outlined in green boxes in each panel.

References:

Wang, P., Leung, L. R., Lu, J., Song, F., & Tang, J.: Extreme wet-bulb temperatures in China: The significant role of moisture, J. Geophys. Res.: Atmos., 124(22), 11944–11960, https://doi.org/10.1029/2019JD031477, 2019b.

Despite the authors properly discuss the results and comparisons shown throughout the manuscript, sometimes the discussion of the different figures in the text does not follow the order of appearance of the different subplots shown within one figure. One example is Figure 5. In the text, the authors refer first to Fig.5d than to Fig.5d, and do the same with Fig.5f and Fig.5e. I would suggest to either fix the test to discuss them in order, or to modify the panel plots to adjust them to the order followed in the text. This would facilitate the reader to follow what the authors are presenting, and the manuscript would be clearer.

Reply: Thanks for your constructive and helpful suggestions. We've modified the panel plots to adjust them to the order followed in the updated manuscript.

We have adjusted the sequence of the subplots in Figure 3:

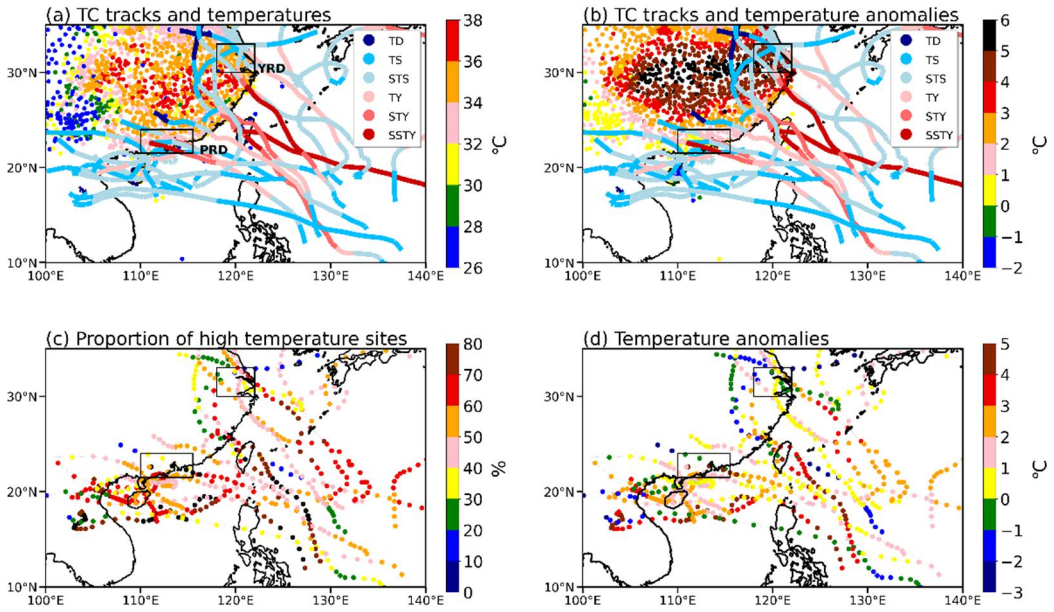

Figure 3. (a) The distribution of average Tmax (dots) and TC tracks during TC-HDs. (b) The Area average of Tmax anomalies during TC-HDs period relative to the summer climatology (June to August of 2014-2019), along with the TC tracks categorized by different intensities. (c) The proportion of high-temperature sites (Tmax ≥ 35℃) over land region of SECC along with the movements of the TCs. The proportion of high-temperature sites refers to the percentage of high-temperature sites within all stations in the SECC region. (d) The average of Tmax anomalies for all observational sites within SECC relative to the summer climatology, along with the movements of TCs. SECC regions are outlined in black boxes in each panel.

We have adjusted the sequence of the subplots in Figures 6-8:

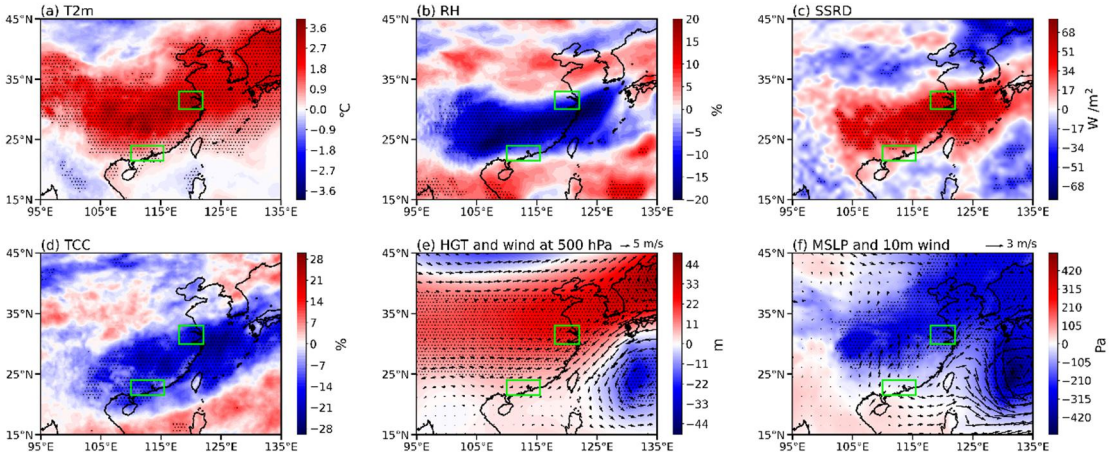

Figure 6. The spatial distribution for the composites anomalies of (a) air temperature at 2m (T2m), (b) relative humidity (RH), (c) surface solar radiation downwards (SSRD), (d) total cloud cover (TCC), (e) geopotential height (HGT) and winds at 500hPa, and (f) mean surface level pressure (MSLP) and 10-meter winds during AHDs relative to the summer climatology. Stippling indicates statistically significant anomalies above 95% confidence level. YRD and PRD regions are outlined in green boxes in each panel.

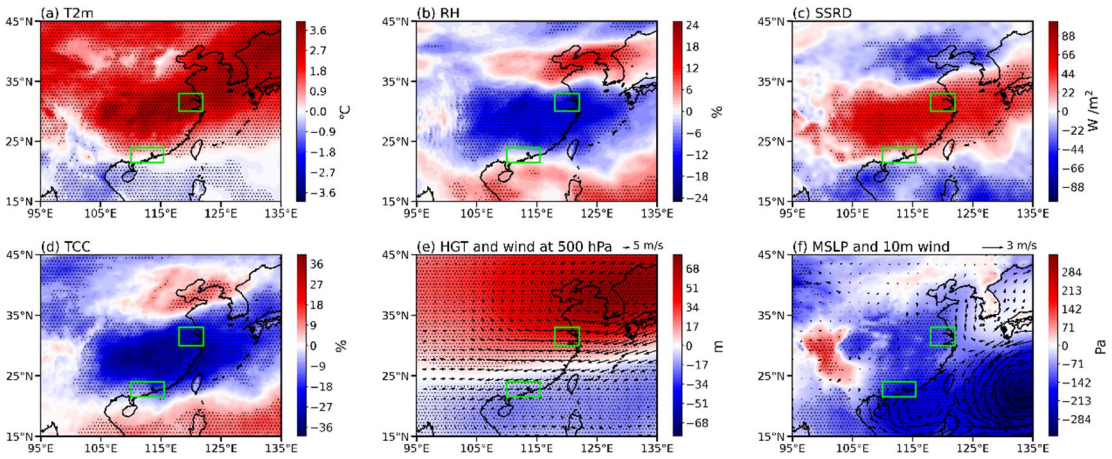

Figure 7. Same as in Figure 6, but for the anomalous meteorological conditions during TC-HDs.

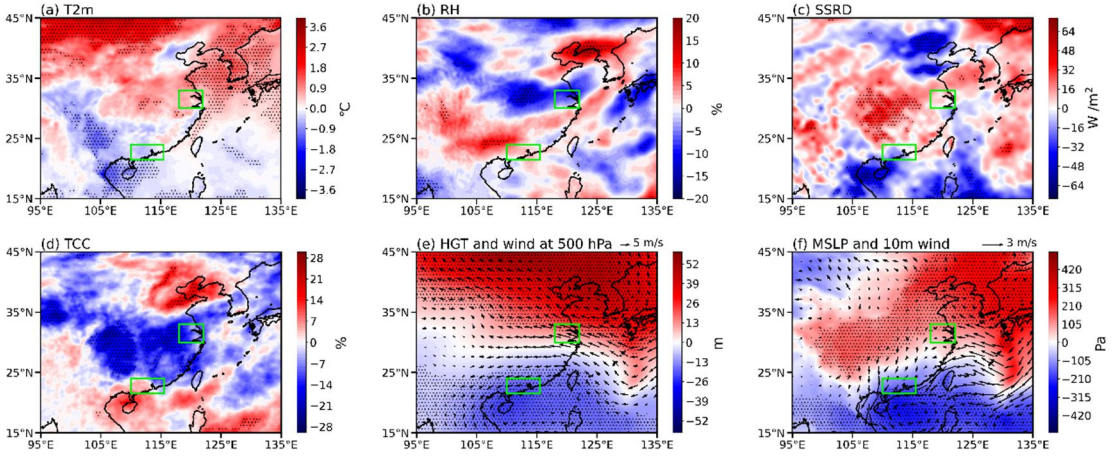

Figure 8. Same as in Figure 6, but for the differences between TC-HDs and AHDs (TC-HDs minus AHDs).

Finally, when analyzing the main physiochemical processes affecting ozone concentration over the selected two areas, it seems that those do not play a relevant role at around 700hPa over the YRD region. Could the authors try to give an explanation why the impact of these processes seems to be not so important at this pressure level over this region?

Reply: Thanks for pointing this out. Figure R1 (see below) shows that the physicochemical processes near 700 hPa in the YRD during the AHD and TC-HD periods have relatively minor effects compared to their contributions at other levels. Consequently, the differences in physicochemical processes between AHDs and TC-HDs around 700 hPa are also relatively smaller. We have added a statement in the updated manuscript for the small effects of physicochemical processes around 700 hPa

(**Lines 385-387**): "The relatively small differences in physicochemical processes between AHDs and TC-HDs around 700 hPa in the vertical profile are due to the minor effects of these processes during both AHDs and TC-HDs (not shown)."

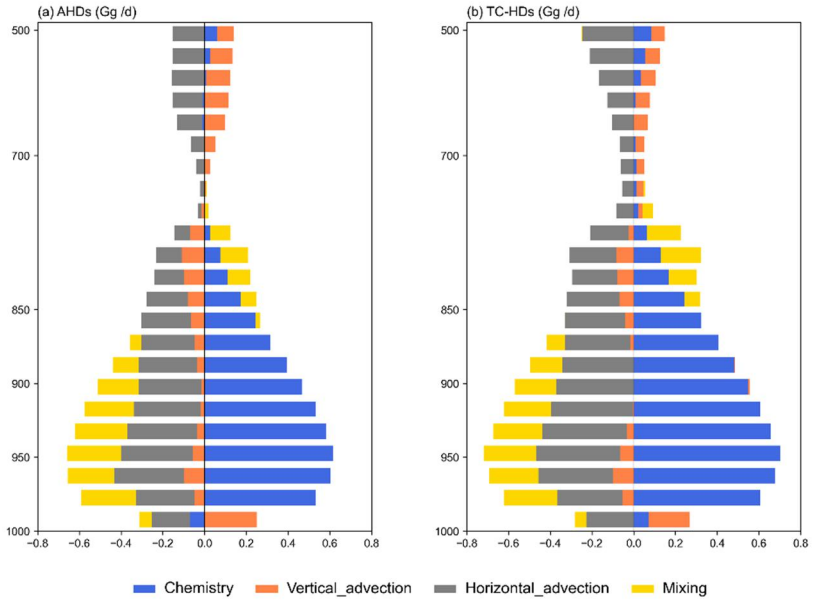

Figure R1. Vertical profile of net changes in ozone mass (Gg O_3/day) for each process over YRD that averaged over all days during AHDs (a) and TC-HDs (b).

Minor Comments:

1. Lines 25-26: maybe the authors mean "more elevated"? Please, check.

Reply: Thanks. Changed.

2. Lines 96-101: I suggest split this long sentence into two to make it easier to read by the reader.

Reply: Thanks. We have shortened the sentences into several shorter ones.

3. Line 187-188: here there are two verbs together. Please, delete one of them for clarity.

Reply: Thanks. Modified.

4. Figure 2: perhaps the authors could replace the black box for SECC in each panel by two smaller ones indicating the YRD and PRD regions. This way, it is clear since the beginning in which parts of the map the reader should focus on. Another option would be to keep the box for SECC and to add the boxes for the two selected regions. Nevertheless, the authors should revise the caption and adapt it to the latest modification for consistency (currently the authors mentioned a red box that now is black).

Reply: Thanks. We have added the boxes for the YRD and PRD in Figure 3 (see below) in the updated manuscript.

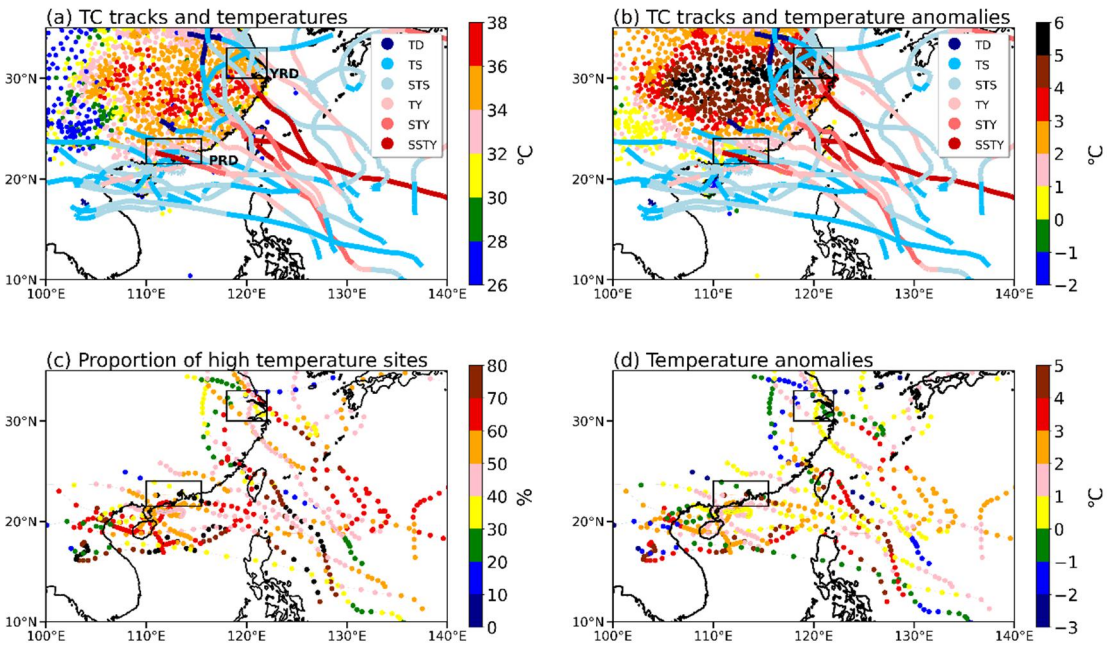

Figure 3. (a) The distribution of average Tmax (dots) and TC tracks during TC-HDs. (b) The Area average of Tmax anomalies during TC-HDs period relative to the summer climatology (June to August of 2014-2019), along with the TC tracks categorized by different intensities. (c) The proportion of high-temperature sites (Tmax ≥ 35°C) over land region of SECC along with the movements of the TCs. The proportion of high-temperature sites refers to the percentage of high-temperature sites within all stations in the SECC region. (d) The average of Tmax anomalies for all observational sites within SECC relative to the summer climatology, along with the movements of TCs. YRD and PRD regions are outlined in black boxes in each panel.

5. Figure 3, line 718: please, replace "minis" by "minus" and "difference" by "different".

Reply: Thanks. Changed.

6. Figure 4: to improve the understanding of this figure, I suggest marking the regions with a different color that does not interfere with the color bar showing ozone concentration.

Reply: Thanks for pointing this out. We have marked the regions with a different color in the updated manuscript (see below).

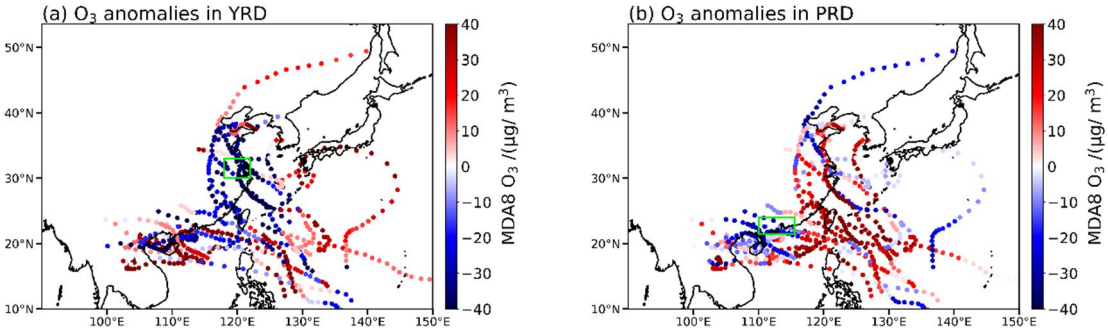

Figure 5. The average anomalies of surface MDA8 ozone concentrations over land regions of SECC along with the movements of TCs associated with TC-HDs for (a) YRD and (b) PRD regions. YRD (a) and PRD (b) regions are outlined in green

boxes in panel (a) or (b).

7. Figure 5: while the selected regions can be seen relatively well in some plots, it is difficult to identify them in others, e.g., Figure 5d. A change of color (e.g., green) of the boxes for each area would improve the clarity of the plots.

Reply: Thanks. The colors of the boxes for each region in Figure 6 have been modified (see below).

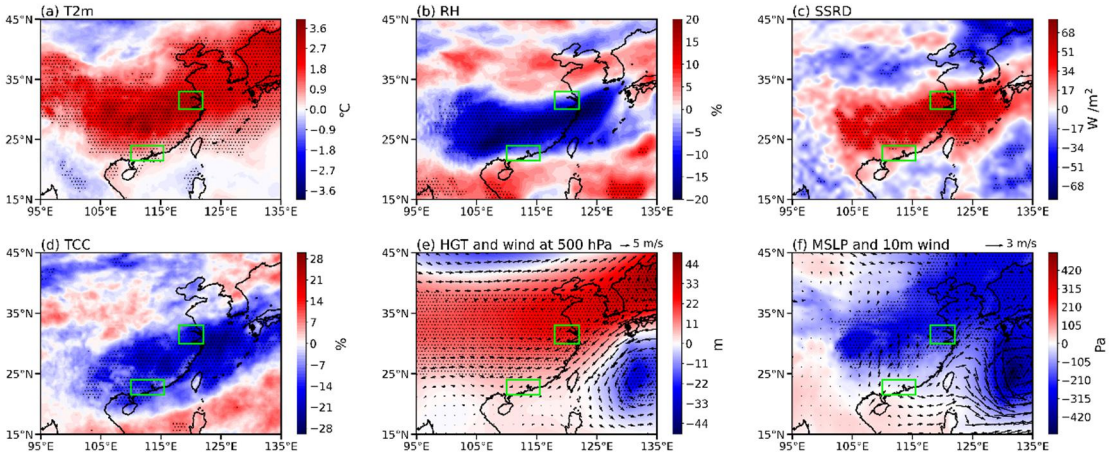

Figure 6. The spatial distribution for the composites anomalies of (a) air temperature at 2m (T2m), (b) relative humidity (RH), (c) surface solar radiation downwards (SSRD), (d) total cloud cover (TCC), (e) geopotential height (HGT) and winds at 500hPa, and (f) mean surface level pressure (MSLP) and 10-meter winds during AHDs relative to the summer climatology. Stippling indicates statistically significant anomalies above 95% confidence level. YRD and PRD regions are outlined in green boxes in each panel.

8. Figure 6: same comment as for Figure 5.

Reply: Thanks. The colors of the boxes for each region in Figure 7 have been modified (see below).

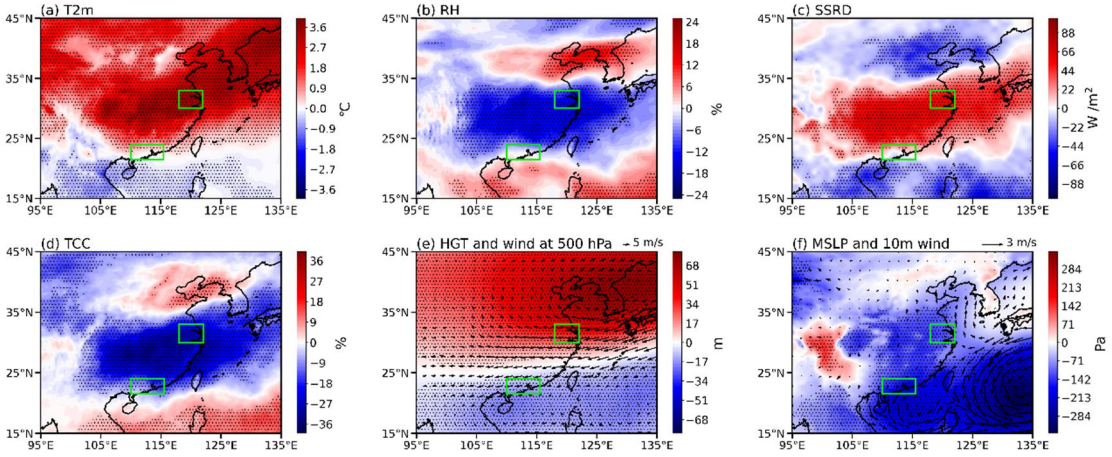

Figure 7. Same as in Figure 6, but for the anomalous meteorological conditions during TC-HDs.

9. Figure 7: same comment as for Figure 5.

Reply: Thanks. The colors of the boxes for each region in Figure 8 have been modified (see below).

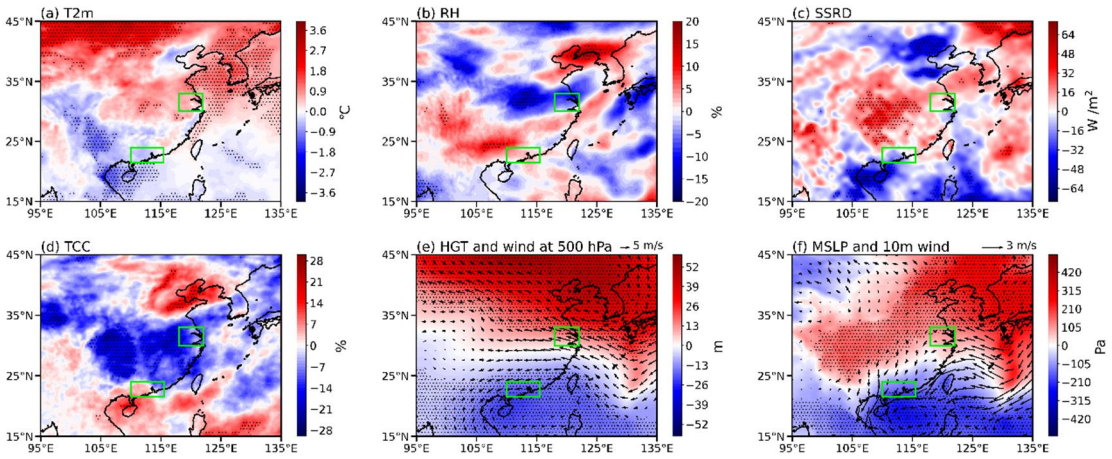

Figure 8. Same as in Figure 6, but for the differences between TC-HDs and AHDs (TC-HDs minus AHDs).

10. Figure 8: the y-axis label is a bit cut. Please, change it.

Reply: Thanks. It has been changed (see below).

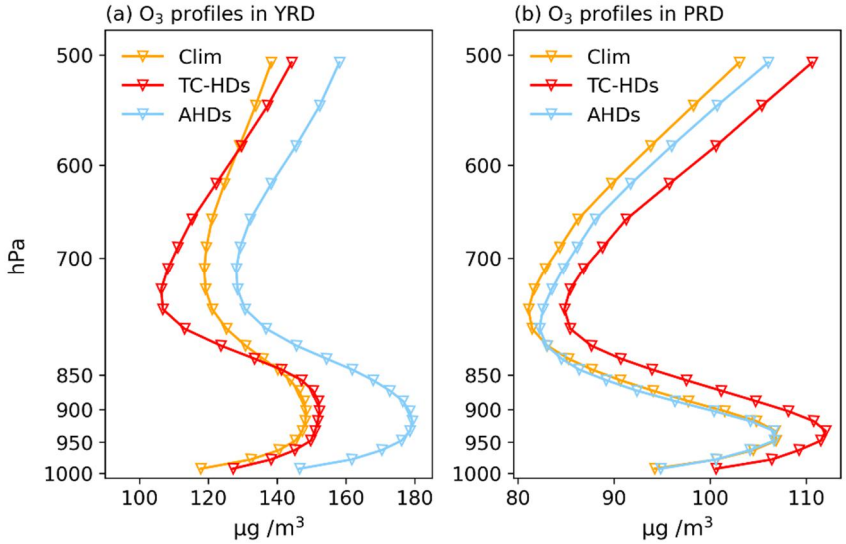

Figure 9. Vertical profiles of simulated daily ozone concentrations (μg/m^3) averaged over land regions of SECC for TC-HDs, AHDs and for the summertime climatology (Clim) during 2014-2019 for (a) YRD and (b) PRD.