Responses to reviewer(s) comments

Anonymous Referee #1:

It is appreciated that the authors took great efforts to elucidate the complex relationship between WPSH and air pollution in China during summer, which is interesting. However, the manuscript was not well organized (synoptic characteristics and their influences on pollution are better given in a section), and most analyses were superficial without observational evidence. The manuscript needs better organization and careful English editing.

RESPONSE: Thank you for your valuable time to review this manuscript. We totally agree with your comments. Therefore, we have reorganized our writing structure thoughtfully in the current version. Particularly, we have carefully provided more information regard to the descriptions associated with synoptic weather characteristics and their influences on pollution. We have also added more information in order to provide in-depth results with observational evidences as suggested.

1. Only four types were identified, which tends to oversimplify the complex synoptic situations during summer in eastern China. By contrast, six types were identified by Han et al. (2020) to understand the influence of synoptic weather on the summertime O3 pollution in eastern China; nine types were classified by Ye et al. (2016) for the aerosol pollution in the North China Plain. The region selected for the classification should be consistent with the studied region (eastern China in Fig. 1). Why use the region shown by the black squares in Fig. 4? And present it in a larger domain in Fig.4? The classified region cannot resolve the processes needed? The selection of the classified region can significantly influence the classification results.

RESPONSE: Many thanks for your kind suggestions. The classification results can be largely influenced by the selected region, seasonal effects, and temporal length (time-series) of samples. We have read through the suggested references from reviewer. We found that Han et al. (2020) objectively identified six predominant synoptic weather patterns (SWPs) at 850 hPa level over eastern China (i.e., 20-40°N, 110-130°E) in the summer during 2013–2018. Ye et al. (2016) applied statistical analyses to identify nine types of synoptic flow based on sea level pressure over the North China Plain during autumn and winter (2004–2014). The settings are quite different from our study. Particularly, we chose a relatively large spatial extent as our classified region (0-60 ° N, 65-150 ° E) to capture the characteristics of the West Pacific Subtropical High (WPSH) at 500 hPa, as this can modulate the weather conditions and resultant co-occurring pollution events over eastern China. In this study, the number of SWP is determined by explained cluster variances (ECV) (Hoffmann & SchlüNzen, 2013; Philipp et al., 2014). The number of synoptic patterns (k) is optimized when the ΔECV is at the highest value, which suggests that the performance of classification has been improved substantially and with stability (Ning et al., 2019).

In order to further address the comments, we have now included a Fig. S1 to present the changes of ΔECV against different numbers of classified synoptic patterns, including how we have optimized four SWPs. We have also marked the location of our classified region on the revised Fig. 4. Furthermore, we have revised our title as "Large-scale synoptic drivers of co-occurring summertime ozone and $PM_{2.5}$ pollution in eastern China".

Reference:

Han, H., Liu, J., Shu, L., Wang, T. and Yuan, H.: Local and synoptic meteorological influences

on daily variability in summertime surface ozone in eastern China, Atmos. Chem. Phys., 20(1), 203–222, doi:10.5194/acp-20-203-2020, 2020.

Hoffmann, P. and Heinke SchlüNzen, K.: Weather pattern classification to represent the urban heat island in present and future climate, J. Appl. Meteorol. Climatol., 52(12), 2699–2714, doi:10.1175/JAMC-D-12-065.1, 2013.

Ning, G., Yim, S. H. L., Wang, S., Duan, B., Nie, C., Yang, X., Wang, J. and Shang, K.: Synergistic effects of synoptic weather patterns and topography on air quality: a case of the Sichuan Basin of China, Clim. Dyn., 53(11), 6729–6744, doi:10.1007/s00382-019-04954-3, 2019.

Philipp, A., Beck, C., Esteban, P., Krennert, T., Lochbihler, K., Spyros, P., Pianko-kluczynska, K., Post, P., Alvarez, R., Spekat, A. and Streicher, F.: Cost733 user guide., 2014.

Ye, X., Song, Y., Cai, X. and Zhang, H.: Study on the synoptic flow patterns and boundary layer process of the severe haze events over the North China Plain in January 2013, Atmos. Environ., 124(January 2013), 129–145, doi:10.1016/j.atmosenv.2015.06.011, 2016.

2. The classification results are odd. For example, in July of 2016, it quickly turned form Type 2 to Type 4, and then became Type 1 during a few days (Fig. 5). The WPSH cannot jump like that (e.g., from Type 2 to Type 4 in 24 hours). Besides, almost the whole June of 2016 was identified as Type 1 (“South BTH-North YRD O_3-$PM_{2.5}$ compound pollution”), while the South BTH and North YRD often experience clean and pollution situations during a few days (https://www.aqistudy.cn/historydata/daydata.php?city=%E5%8D%97%E4%BA%AC&month=201606). The synoptic pattern of Type 1 cannot explain the formation and evolution of pollution in South BTH and North YRD. The variations of pollution level may be primarily controlled by other synoptic weather systems at 900/850-hPa, rather than the 500-hPa WPSH. The same problems also existed in other Types/regions. The classification results and their relationships with pollution are suspicious and unreliable.

RESPONSE: Thank you for pointing out the “odd” results. In our study, the movement of the WPSH is generally affected by the weather phenomenon of its surrounding climatic systems (such as typhoons, the Tibetan high, etc.) (Ge et al., 2019; Liu and You, 2020; Shu et al., 2016). In order to address this comment, we have now included a Fig. R1 to show the synoptic weather patterns at 500hPa between July 05, 2016 and July 08, 2016. Our results showed that the weather pattern has first quickly changed from Type 2 to Type 4, then finally became a Type 1 pattern under the influence of Super Typhoon Nepartak (Fig. R2). Particularly, our statistical analyses showed that Type 1 pattern can represent the conditions of compound pollution events. Under the influence of this large-scale synoptic pattern, there is a relatively high probability of the occurrence of compound pollution in the BTH-NYRD region, with the maximum occurrence probability reaching to 55.09%. These variations of air pollution level may be primarily controlled by other synoptic weather systems at 900/850-hPa closely related to the movement of WPSH. Additionally, moisture driven by the WPSH could create inconducive condition for the O_3 formation across South China(Zhao and Wang, 2017). Furthermore, the amount of water vapor is largely reduced as it has been transported to North China through airflow trajectories, resulting in a moderation of RH and high temperature over North China which enhance the formation of O_3-$PM_{2.5}$ co-occurring event.

More importantly, one aim of our study was to examine the effect on O_3-$PM_{2.5}$ co-occurring event caused by the large-scale WPSH related synoptic

pattern. As WPSH at 500-hPa is easily identified based on 5880 gpm contour line, we applied the following condition (500 hPa GH) as our dependent variable for classification. In order to further address this comment, our revised Fig.R3 has shown the synoptic weather pattern at 850 hPa corresponding to the classification. This figure can represent matching characteristics of the WPSH at 850 hPa and 500 hPa (Fig.4 and Fig. R3). Based on the comparison, using 500hPa GH for classification should be accurate and reliable in this study.

Reference

Ge, J., You, Q. and Zhang, Y.: Effect of Tibetan Plateau heating on summer extreme precipitation in eastern China, Atmos. Res., 218, 364–371, doi:10.1016/j.atmosres.2018.12.018, 2019.

Hoffmann, P. and Heinke SchlüNzen, K.: Weather pattern classification to represent the urban heat island in present and future climate, J. Appl. Meteorol. Climatol., 52(12), 2699–2714, doi:10.1175/JAMC-D-12-065.1, 2013.

Huth, R.: An intercomparison of computer-assisted circulation classification methods, Int. J. Climatol., 16(8), 893–922, doi:10.1002/(SICI)1097-0088(199608)16:8<893::AID-JOC51>3.0.CO;2-Q, 1996.

Liu, J. and You, Q.: A diagnosis of the interannual variation of the summer hydrometeor based on ERA-interim over Eastern China, Atmos. Res., 231(October 2018), 104654, doi:10.1016/j.atmosres.2019.104654, 2020.

Philipp, A., Beck, C., Esteban, P., Krennert, T., Lochbihler, K., Spyros, P., Pianko-kluczynska, K., Post, P., Alvarez, R., Spekat, A. and Streicher, F.: Cost733 user guide., 2014.

Shu, L., Xie, M., Wang, T., Gao, D., Chen, P., Han, Y., Li, S., Zhuang, B. and Li, M.: Integrated studies of a regional ozone pollution synthetically affected by subtropical high and typhoon system in the Yangtze River Delta region, China, Atmos. Chem. Phys., 16(24), 15801–15819, doi:10.5194/acp-16-15801-2016, 2016.

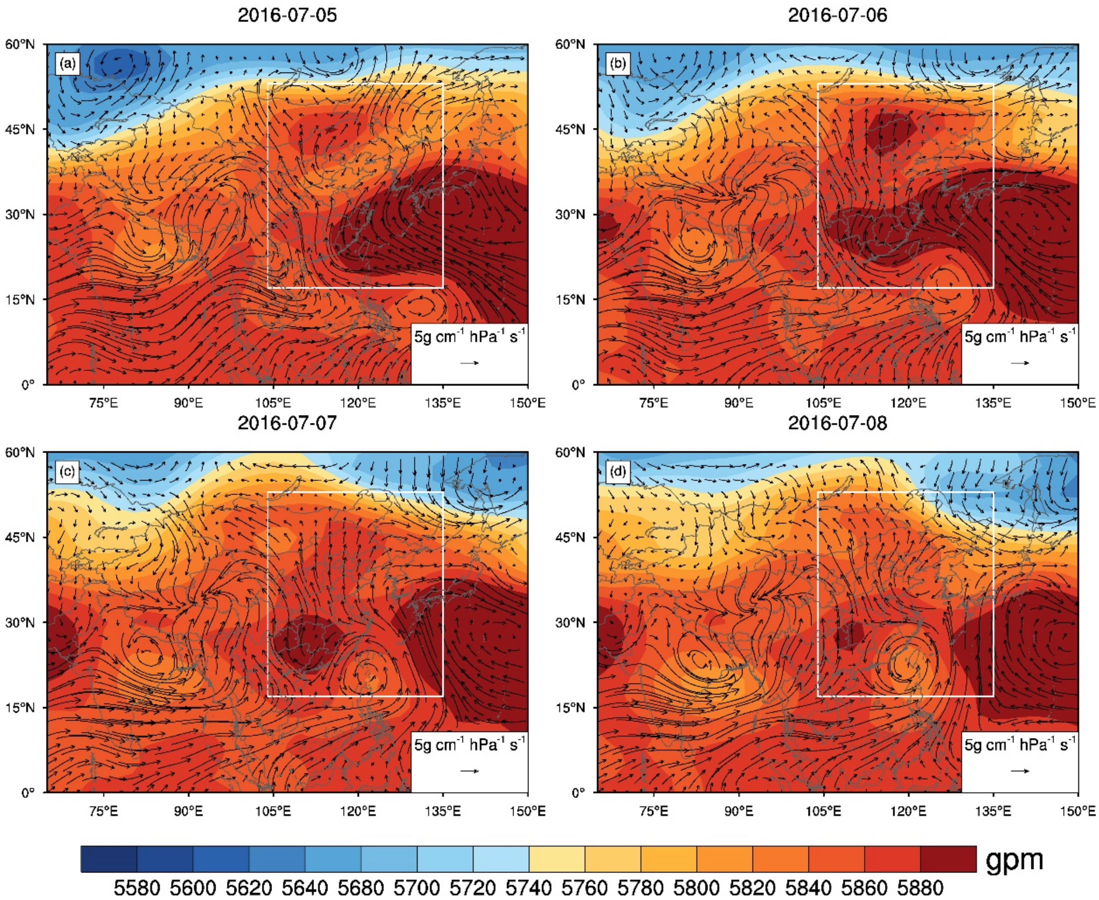

Fig. R1. the case during July 5-8,2016

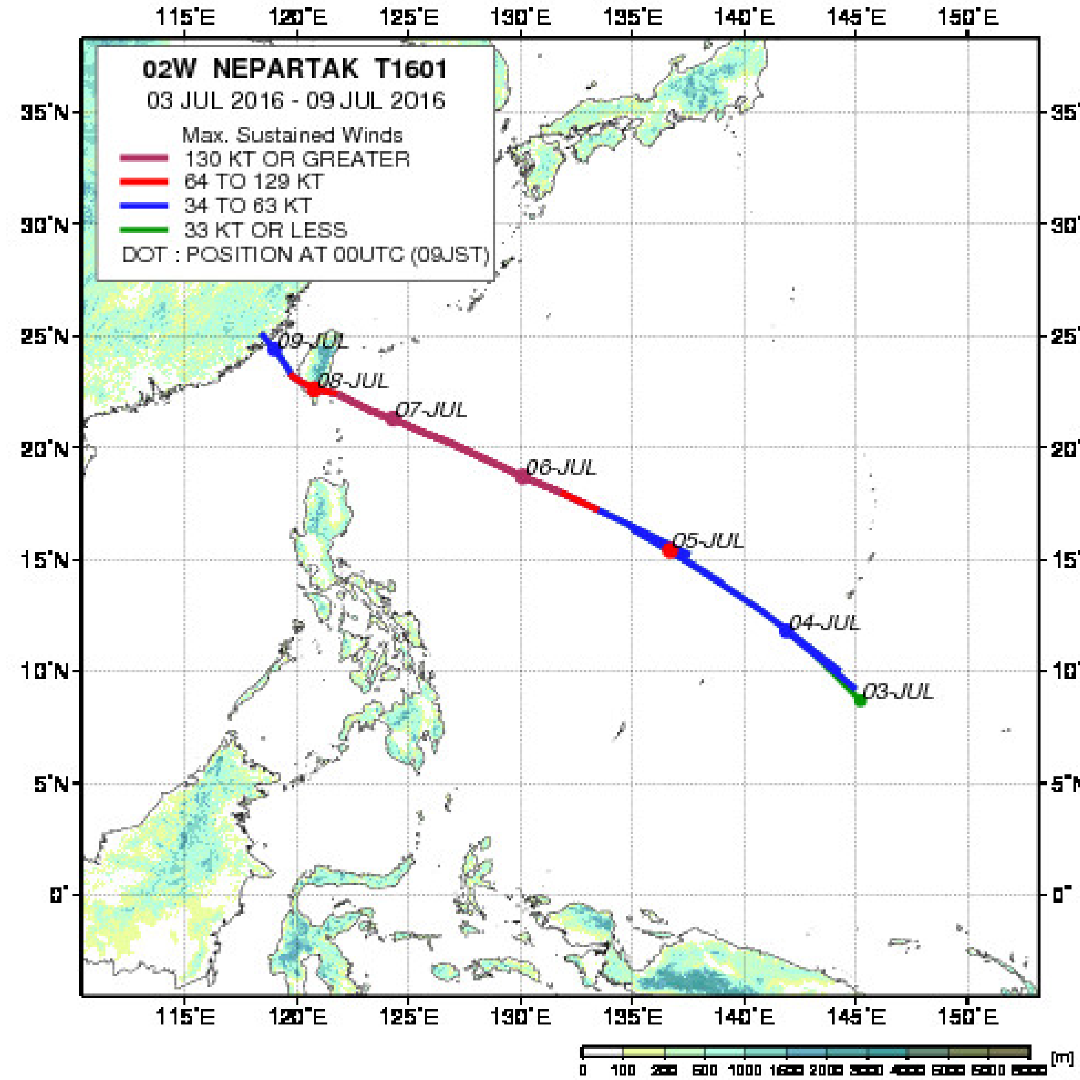

Fig. R2. Track of Super Typhoon Nepartak. This figure can be downloaded on the website (https://sharaku.eorc.jaxa.jp/TYP_DB/data/TYP_DB_COMMON/track/bst_2016s.02W.NEPARTAK.jpg).

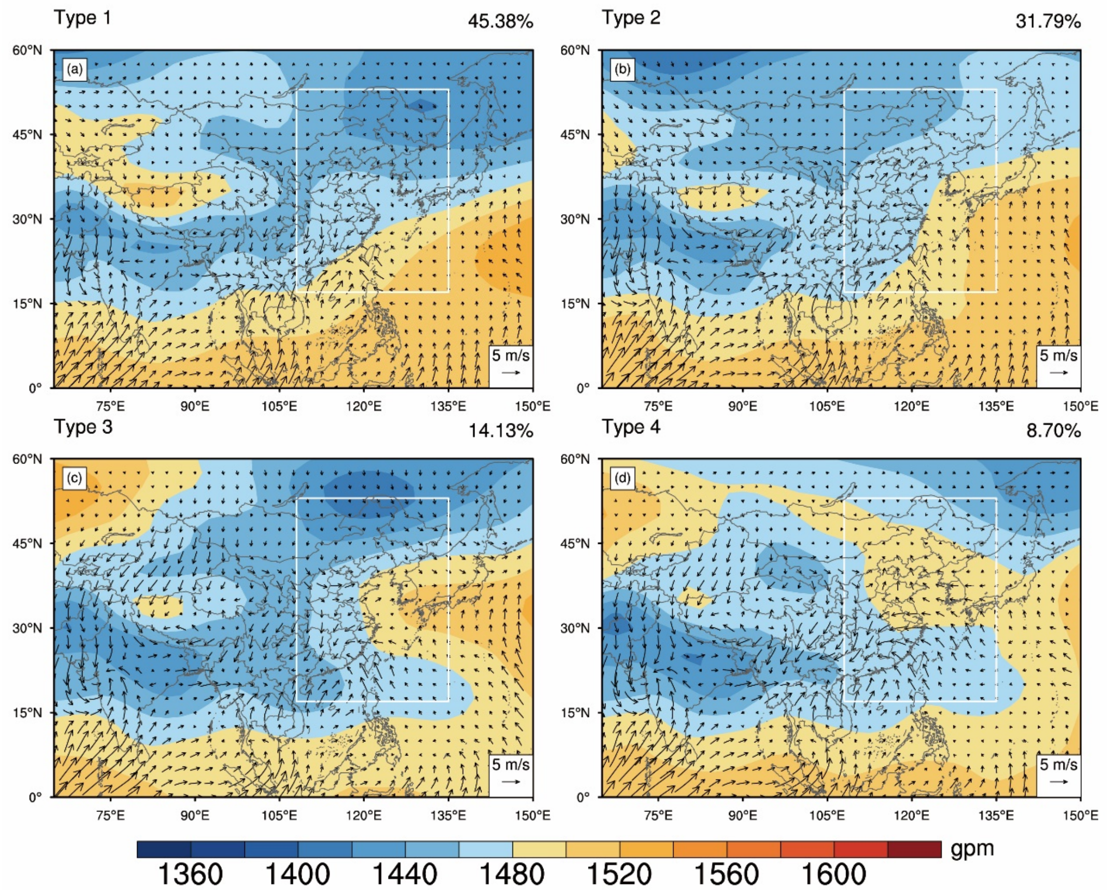

Fig. R3. The 10-m wind (vectors; see scale arrow at the bottom right in units of 5 m/s) and 850-hPa GH (contours; see scale bar at bottom in units of gpm) patterns based on objective classification

3. Physically, the synoptic weather patterns influence the pollutions via PBL structure (e.g., large-scale subsidence), regional-scale transport of pollutants (e.g. PM2.5 and VOCs), and occurrence of precipitations. All these physical processes underlying were not well analyzed. The authors cannot just use simple correlation analysis to explain the mechanisms, which makes the conclusion unreliable and inconvincible. At least, typical pollution episodes of each synoptic weather type should be analyzed in-deep with observational evidence to validate the hypothesis given.

RESPONSE: Based on your suggestions, this study has now considered the role of boundary layer structure in modulating the pollution. Particularly, we conducted an in-depth analysis of the compound pollution under Type 1 and Type 2 patterns. The underlying physical mechanism would be explained by our investigation regarding the characteristics of boundary layer structure, precipitation and ground-level wind flow over the polluted regions. More descriptions have now been noted on lines 410-424. Please also find the information below.

"Furthermore, we summarized boundary layer structure, precipitation, and ground-level wind flow across the BTH region. Based on the characteristics, we separately defined Type 1 and Type 2 into clean (both concentrations of the O_3 and $PM_{2.5}$ are less than polluted level) and compound pollution periods (Figs. 11 and S10-S11). Particularly, Type1 has a significantly warmer temperature over the boundary layer during the compound pollution period of BTH region than that of the clean period. The daytime BLH under compound pollution condition

was also higher than that of the clean condition. In addition, there were different directions of prevailing during the two periods, which prevailing winds during the compound pollution period were usually southward and could be driven by air pollutants transported from the southern plains (Fig. 11; see also Miao et al., 2019b, 2020). Co-influencing by the topographical effect of the northern mountainous areas, air pollutants could be trapped in the BTH region. In comparison, although there was southward wind prevailing in the BTH region (Figs. 11 and S11), the rain belt also located in the southern area of BTH might lead to the potential removal of $PM_{2.5}$ (Fig. 9j). Therefore, compound pollution across the BTH region might mainly be due to local emissions of air pollutants."

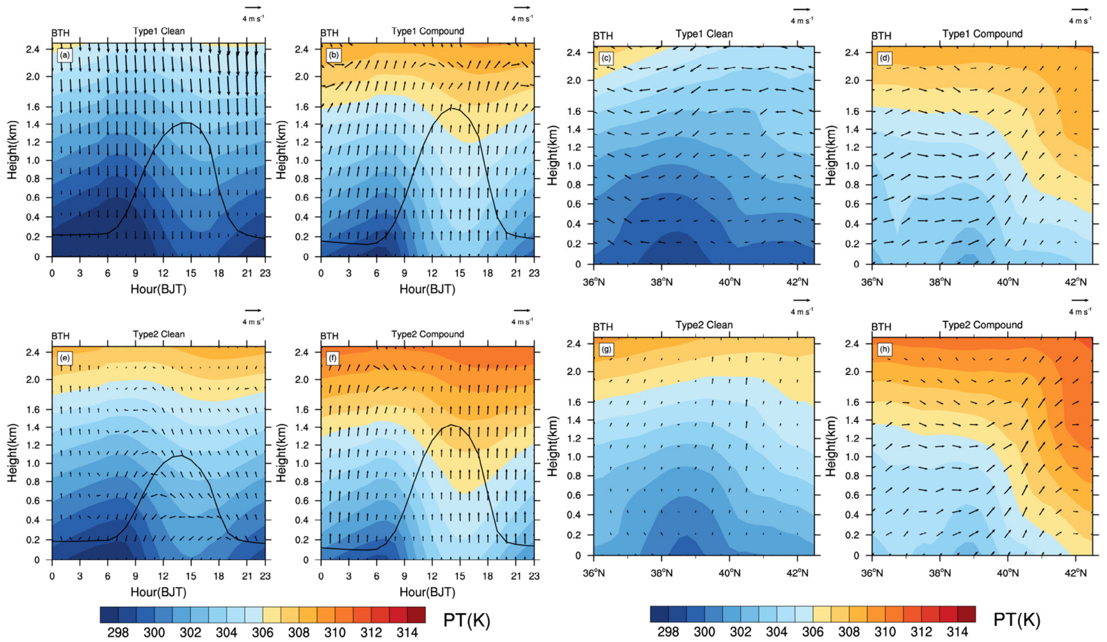

Fig. 11. The daily variation of horizontal wind, potential temperature (PT) and BLH of boundary layer in the BTH under clean and compound pollution period of Type 1 and Type 2 (a, b, e, f). The vertical cross-section of u-wind, w-wind and PT for the same situation of BTH (c, d, g, h). The w-wind is multiplied by 100 when used. The data has been derived from ERA5 reanalysis data.

4."The BLH was calculated according to the method given by Guo et al. (2016, 2019), and the FLWD [frequency of light wind (< 2 m s−1) days], precipitation frequency (PF), and MDA8 O3 were also counted." The detailed information about BLH should be directly given. At present, only a few cities have afternoon soundings during summer. Only 08:00 and 20:00 LT soundings were used to calculate the BLH, which is inappropriate for this study. How to calculate the FLWD and PF? Why only choose these specific parameters? Are they significantly correlated to the pollution levels in all the studied regions (e.g., BTH, YRD, GZP)? How about the precipitation intensity and amount, and its lasting time? How about the wind directions and wind shear, and associated transport of pollutants (PM2.5 and VOCs)?

RESPONSE: Thanks for the comments. More information regarding BLH has now been added in supplementary materials. Please find the details as follows:

"The bulk Richardson number (*Ri*) was applied to calculate the BLH.

Ri can be expressed as:

$$R(i) = \frac{(g/\theta_{vs})(\theta_{vz}-\theta_{vs})(z-z_s)}{(u_z-u_s)^2+(v_z-u_s)^2+(bu_*^2)} \quad (1)$$

where z is height above ground, s is the surface, g is the acceleration due to gravity, θ_v is virtual potential temperature, u and v are the component of wind speed, and u_* is the surface friction velocity. Due to a much smaller magnitude in compared with bulk wind shear term in the denominator, this study does not need to consider the influence of u_* (Seidel et al., 2012).". Furthermore, our revised study has now applied 14:00 LT soundings to estimate the BLH, while the results of BLH at 08:00 and 20:00 LT soundings (calculated in original version) were reported in supplementary materials as references (Fig. S13). Specifically, we have added the following variables for calculation: FLWD and PF. Specifically, FLWD is the frequency of light wind (< 2 m s^{-1}) days, which can be defined as the ratio between the number of the days with average daily WS lower than 2 m s^{-1} and the total days of each synoptic pattern; PF is precipitation frequency, which can be defined as the ratio of the number of the rainy days to the total days associated with each synoptic pattern). The above definitions were due to an unfavorable condition for transporting air pollutants during low WS days as well as low possibility of forming O_3-$PM_{2.5}$ co-occurring pollution during low PH conditions. We also applied specific meteorological parameters associated with air pollution levels in this study, such as Tmax, RH and BLH. Based on our results, we also found that Tmax can exceed 27°C during high O_3 events across five urban clusters of the study area, and moderate RH can be associated with O_3-$PM_{2.5}$ compound pollution in the BTH region and North YRD area. Furthermore, high BLH can enhance the environmental capacity of atmospheric pollutants resulting in a reduction of air pollutant concentration. Additionally, there was not a significant difference of the average daily precipitation among the four types of synoptic weather patterns (Fig. R4). However, we have found a significant difference of precipitation level during clean and compound pollution period under the same SWP (see Figure S10 and S11). Due to a lack of hourly precipitation data, this study cannot show the intensity and lasting time. Therefore, we have now added more information regarding this in the limitation section, as well as a suggestion regarding the future improvement with high-temporal-resolution data.

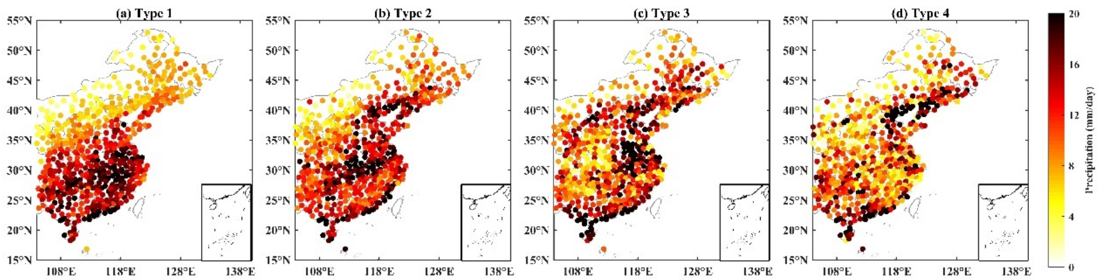

Fig. R4. The daily mean amount of precipitation under each SWPs.

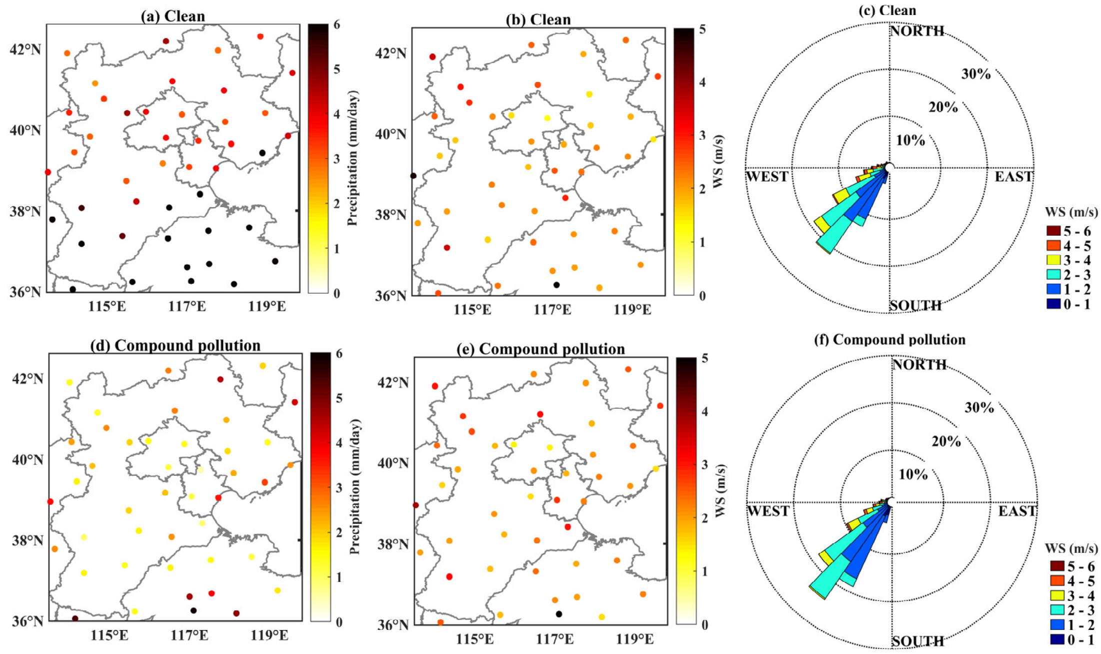

Fig. S10. Precipitation, WS, and WD during clean and compound pollution period under Type 1 over BTH.

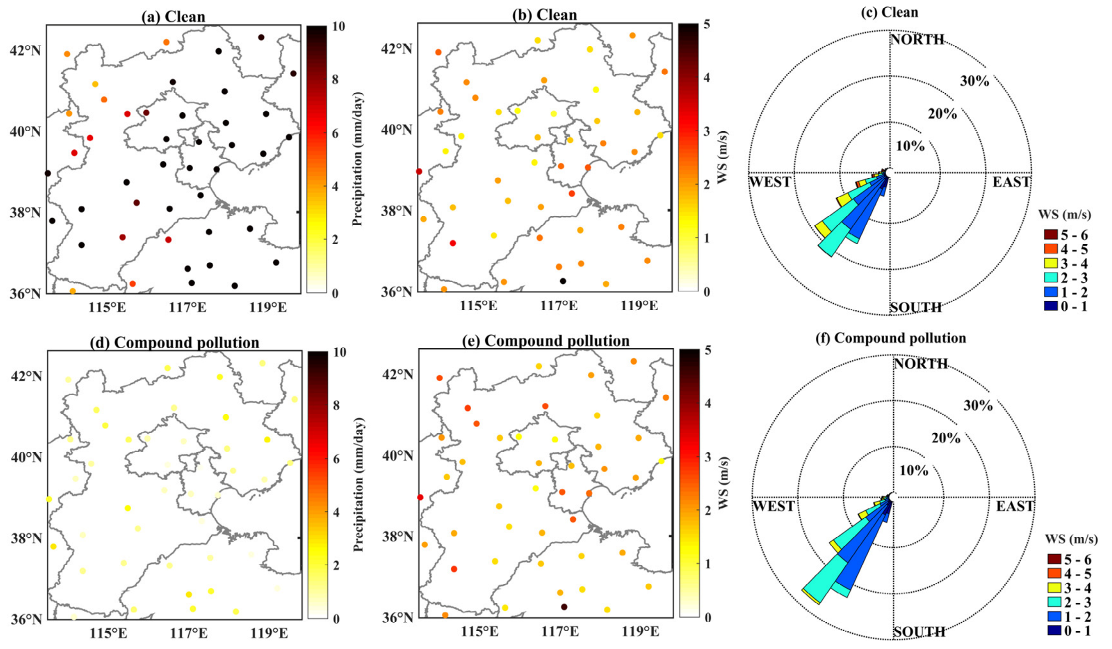

Fig. S11. Same as Fig. S8 but for Type 2.

5. In the Results and Discussion sections, the "rain belt", "Meiyu", "rain band", "heavy precipitation" were simply analyzed with very few observational evidence. Since this study focuses on the movement/evolution of WPSH in summer (rainy season), more in-deep analysis on the links between precipitation and pollutions should be given with observational evidence and typical episodes.

RESPONSE: Thanks for your suggestion. It is indeed our limitation as the position of the rainband could only be sketchily plotted based on the frequency and volume of precipitation under each SWP (Fig. 8i-l). Therefore, this study aimed to characterize the trend and location of rain belt in relation to the movement of WPSH in summer, based on separate discussions with each SWP. More information can be referred as follow: "Type 1 is characterized by humid condition in the southern area and dry condition in the northern region owing to an extensive southwestern flow of the WPSH, resulting in a rain belt found in southeastern coastal area such as PRD and YRD regions. Type 2 is associated with meridional flow and dry and wet anomalies in northern China, resulting in a rain band locating at the central areas of between BTH and YRD regions due to the northern advance of the WPSH compared with Type 1. Furthermore, there is a greater RH for most of the study sites under Type 3 and Type 4, possibly a result of the shifted rain belt in the BTH and NEM regions under Type 3 once the northern boundary of the WPSH reaching at 37.5°N, and an occurrence of heavy precipitation across the western PRD region as well as central areas of between BTH and YRD regions under Type 4 (Fig. S6).".

Additionally, we have now shown the linkages between precipitation and compound pollution in Figs. S10 and S11 as well as the response of the last question, with evidences showing that precipitation amount during clean period is greater than that of the polluted period over the BTH region.

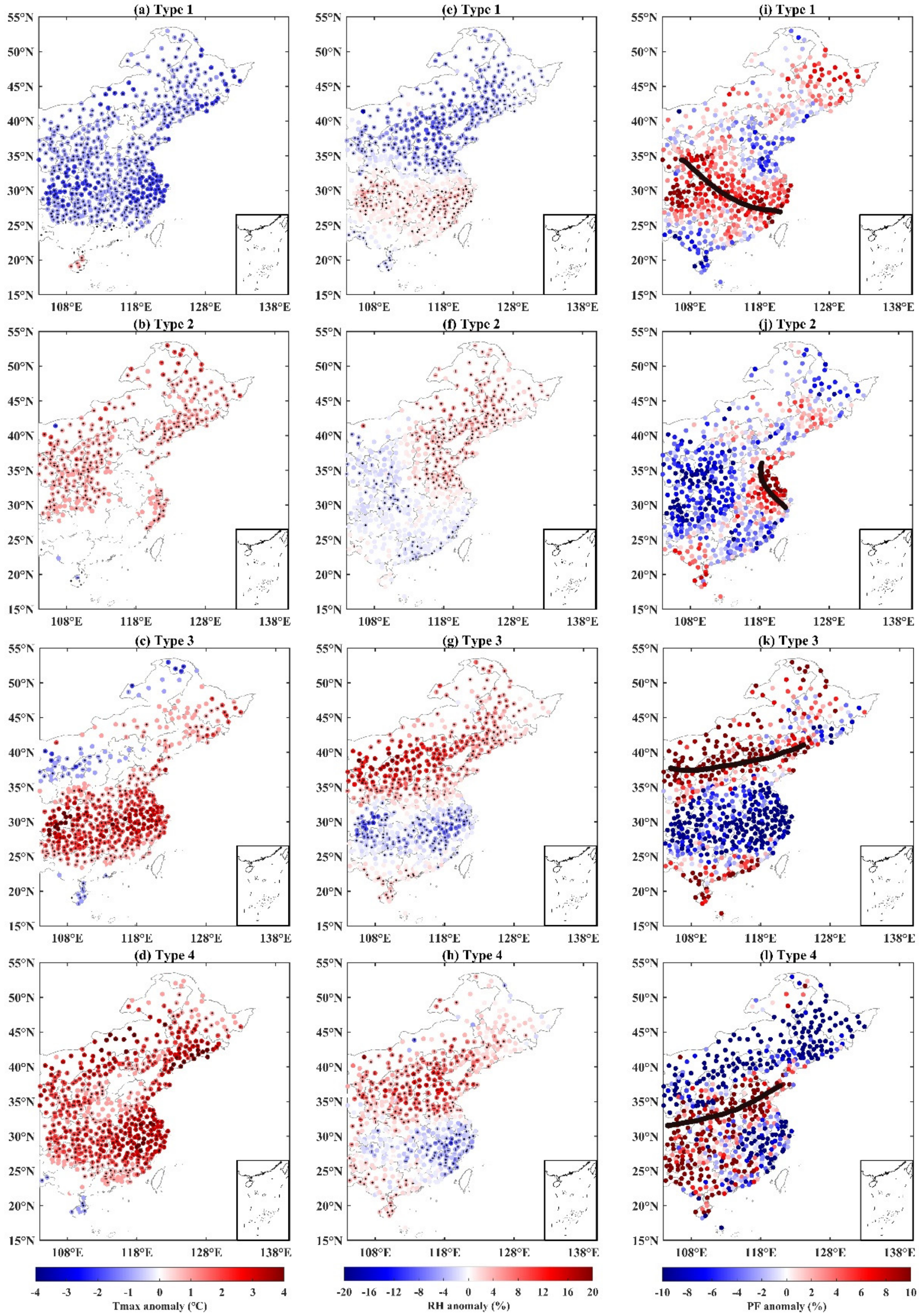

Fig. 8. Same as Fig. 6 but for Tmax (a–d), RH (e–h), and PF (i–l). The black solid line presents the rain belt of each SWP.

6.Section 4.2 "Effects of NO2 on O3". The best proxy of photochemical reactivity is the ozone potential efficiency (OPE) but not the ratio of O3 to NO2. High photochemical reactivity probably appeared with high O3 and NO2 concentration but reasonably with a low O3/NO2 ratio. It is not accurate to take the O3/NO2 ratio as the judging criteria.

RESPONSE: Many thanks for your kind suggestion. Indeed, ozone potential efficiency (OPE) is the best proxy of photochemical reactivity, however, the related data for calculation was unavailable. As an alternative, previous studies have demonstrated that the photochemical reaction of NO, NO2, and O_3 in the troposphere form could a closed system(Yu et al., 2020), and this photochemical cycle of NOx and O_3 could be the basis of photochemical processes in the troposphere. Therefore, oxidant (Ox, Ox=O_3+NO_2), a conservative quantity over a short temporal scale, could be an alternative parameter to evaluate photochemical processes because NO can quickly react with the equivalent amount of O_3 to generate NO_2(Kley et al., 1994). Particularly, some studies have demonstrated that Ox could be used to represent OPE (Chang et al., 2020; Ge et al., 2013). Therefore, we used Ox to be an alternative of OPE, not the ratio of O_3 to NO_2 in the last manuscript.

Based on these assumptions, we further revised our content. For example, revised, "Figure 10 can present the daily variation of NO_2 and Ox. These include daily variations of NO_2 showing two peaks during a day, including a first peak at the morning and an second peak associated with traffic emissions in the evening (Xie et al., 2016; Yu et al., 2020). As we found the lowest point of NO_2 at 15:00 (BJT), and NO_2 can be photolyzed to produce O_3 during the day, this study assumed that this particular time was the peak formation ozone across the study areas. As NO_2 was consumed through a photochemical reaction with the involvement of other precursors to produce a large amount of O_3, Ox could form a peak during the afternoon. In particular, abundant sunlight in summer is beneficial to the photochemical reaction process, but since most parts of eastern China are in a subtropical climate with the same period of rain and heat, the existence of the rainy season will inevitably inhibit the summer photochemical process. Under different SWP, the photochemical reaction over each area has an obvious relationship with the rain belt. For example, the rainy season in BTH and NEM areas mainly occurs in Type 3, and the Ox of Type 3 in this area is significantly lower than other SWPs.". Therefore, we have changed the section title from "Effects of NO_2 on O_3" to "Potential implications of NO_2".

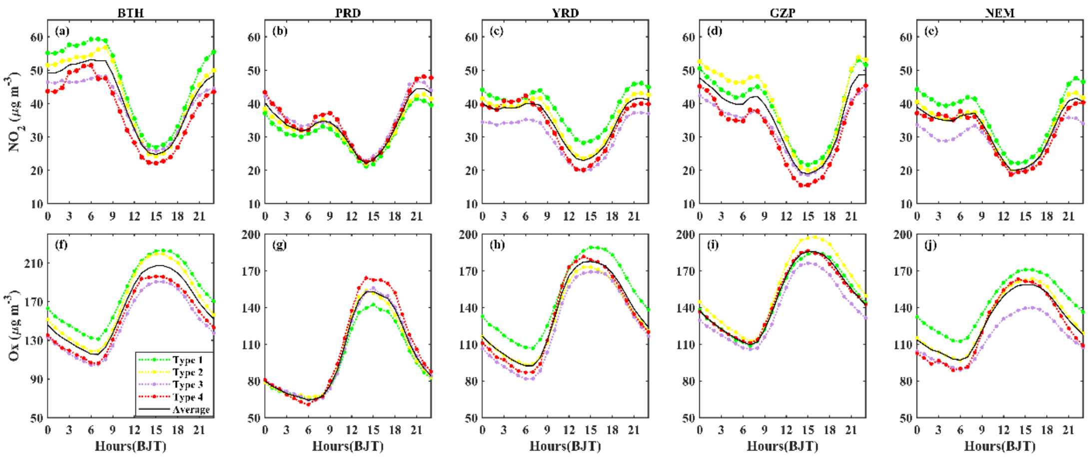

Fig. 10. Daily variation of NO_2 and Ox under four SWPs in key urban clusters.

Reference

Chang, L. S., Choi, J. Y., Son, J., Lee, S., Lee, D., Jo, Y. J. and Kim, C. H.: Interpretation of decadal-scale ozone production efficiency in the Seoul Metropolitan Area: Implication for ozone abatement, Atmos. Environ., 243(April), 117846, doi:10.1016/j.atmosenv.2020.117846, 2020.

Ge, B., Sun, Y., Liu, Y., Dong, H., Ji, D., Jiang, Q., Li, J. and Wang, Z.: Nitrogen dioxide measurement by cavity attenuated phase shift spectroscopy (CAPS) and implications in ozone production efficiency and nitrate formation in Beijing, China, J. Geophys. Res. Atmos., 118(16), 9499–9509, doi:10.1002/jgrd.50757, 2013.
Kley, D., Geiss, H. and Mohnen, V. A.: Tropospheric ozone at elevated sites and precursor emissions in the United States and Europe, Atmos. Environ., 28(1), 149–158, doi:10.1016/1352-2310(94)90030-2, 1994.
Xie, M., Zhu, K., Wang, T., Chen, P., Han, Y., Li, S., Zhuang, B. and Shu, L.: Temporal characterization and regional contribution to O 3 and NO x at an urban and a suburban site in Nanjing, China, Sci. Total Environ., 551–552(x), 533–545, doi:10.1016/j.scitotenv.2016.02.047, 2016.
Yu, S., Yin, S., Zhang, R., Wang, L., Su, F., Zhang, Y. and Yang, J.: Spatiotemporal characterization and regional contributions of O3 and NO2: An investigation of two years of monitoring data in Henan, China, J. Environ. Sci. (China), 90(November), 29–40, doi:10.1016/j.jes.2019.10.012, 2020.

Specific comments:

1. Fig. 5, two “2017”?

RESPONSE: Thank you for the comment. We have now revised the words on Figure 5 as suggested.

2. “BTH, YRD, PRD, Guanzhong Plain (GZP), Northeast Megalopolis (NEM) regions”, the locations of these studied regions should be clearly described in manuscript and presented in the Figure.

RESPONSE: We have now added more descriptions regard to the location of study regions (Lines 165-171 of page 7). Please also find more information as follow: “Summer hourly data (2015-2018) for 1174 stations were retrieved from an observational network in eastern China (104°–135°E, 17°–53°N), which include the more prominent pollution areas in the eastern urban agglomeration, such as the BTH (113.5°–119.8°E, 36°–42.6°N), YRD (115.3°–122.6°E, 27.2°–34.5°N), PRD (112.5°–113.7°E, 21.3°–23.1°N), Guanzhong Plain [(GZP) (104.6°–112.2°E, 33.3°–36.8°N)], Northeast Megalopolis [NEM (121.2°–131.0°E, 39.8°–47.3°N)] regions (the specific locations of stations and urban agglomerations are shown in Fig. 1a).”, and the specific locations of stations and urban agglomerations are shown in Fig. 1a.

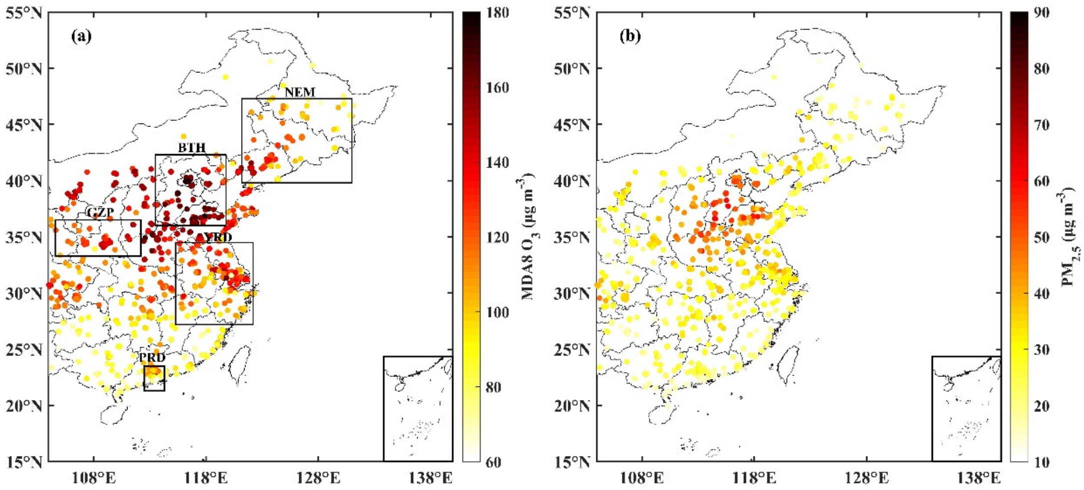

Fig. 1. Average concentration of MDA8 O_3 (a) and $PM_{2.5}$ (b) in eastern China during summers of 2015–2018. Stations and key urban clusters (black boxes) are shown in (a).

3. Line 165-166, "More detailed information about the T-PCA method can be found in Miao et al. (2017)." The detailed information of the method should be directly given.

RESPONSE: More detailed information regarding the T-PCA method is now added to lines 191-197 on pages 7-8:

"The cost733class is a FORTRAN software package consists of several modules for classification, evaluation and comparison of weather and circulation pattern. First, T-PCA classification of the cost733class performs spatial standardization on weather data. Then split data to 10 subsets and estimates principal components (PCs) of weather information based on singular value decomposition, the PC score for each subset can be calculated after oblique rotation, and compares 10 subsets based on contingency tables to select the subset with highest sum and return its types (Miao et al. 2017)."

4. Some literatures were not properly cited. Please carefully check the citations of the whole manuscript. Some are given below. "In general, PM2.5 pollution is featured with obvious diurnal and seasonal changes. Due to the influence of atmospheric diffusion conditions such as precipitation and wind speed (WS), it tends to be enhanced in the morning and evening, lower at noon, and higher in winter and lower in summer." Dose the author mean that the diurnal variations of precipitation and wind speed modulate the pollution level? It is odd. How about the emission and PBL?

RESPONSE: Thanks for your comments. We have revised our content as follow: "In general, a significant diurnal variation of $PM_{2.5}$ pollution was observed, possibly due to obvious the local emissions caused by industrial production and human activities for daily living (Amil et al., 2016; Liu et al., 2019). Particularly, the pollution level was higher during the morning and evening of a normal weekday, with a weakening effect found in the afternoon which may be caused by the co-effects of boundary layer structure as well as anthropogenic emissions. There was also a seasonal variation of $PM_{2.5}$ pollution across China, indicating a higher level of pollution in winter than summer (Ye et al., 2018; Zhang and Cao, 2015)". (lines 66-72 of page 3).

5. “Summer O3 pollution has gradually been prominent, replacing PM2.5 as the primary pollutant in the air…” Is it true? At present, PM2.5 still is the dominant pollutant in China.

RESPONSE: We have revised the sentence as follow: “While $PM_{2.5}$ is still one of the dominant air pollutants across China, surface O_3 pollution in summer has gradually been prominent. Several studies even indicated that O_3 might have replace the role of $PM_{2.5}$ as the primary air pollutant during summer (Li et al., 2019).”.

6. “Miao et al. (2015) suggested that strong northwesterly synoptic winds, low BLH (boundary layer height), high RH and stable atmosphere are more prone to aerosol pollution in the BTH region during wintertime …” The strong northwesterly winds would favor the dispersion of pollutants in winter.

RESPONSE: Thank you for the information. We have revised the content as follow: “Miao et al. (2015) suggested that low boundary layer height (BLH) and stable atmosphere would be an unfavorable condition for the dispersion of winter aerosol pollution over the BTH region.”.

7. “Shi et al. (2020) studied the spatial distribution of O3-8h (O3 8-hour moving average) and PM2.5, and their sensitivity of meteorological parameters; pronounced positive (negative) correlation between temperature (BLH and absolute humidity) and O3-8h was found, but the relation between WS and O3-8h was spatially different; for PM2.5, it was negatively (positively) correlated with temperature, WS and BLH (absolute humidity).” It is another inappropriate citation. Please carefully read the previous study (Shi et al., 2020) and properly introduce it.

RESPONSE: Thank you for the information. We have revised the content as follow:

“ Shi et al. (2020) studied the sensitivity of O_3-8h (O_3 8-hour moving average) and $PM_{2.5}$ associated with meteorological parameters. This study focused on the air pollution and meteorological conditions between January and July, 2013, with a result showing that temperature could have the greatest impact on the daily maximum O_3-8h, while the $PM_{2.5}$ sensitivities are negatively (positively) correlated with temperature, WS, and BLH (absolute humidity) in most regions of China.”.

8. “Recently, Han et al. (2020) revealed that meteorological factors can explain ~46% of the daily variability in summertime surface O3, while synoptic factors contribute to ~37% of the overall meteorological effects on the daily variability of surface O3 in eastern China.” More detailed information on Han et al. (2020) should be presented since it is quite similar to this study, such as its studied period, method, and classification results?

RESPONSE: Thanks for your comments. More details regard to the results of Han et al. (2020) have now been presented in the revised manuscript (lines 110-116 of page 5):

“Recently, Han et al. (2020) assessed the impacts of local and synoptic meteorological factors on the daily variability of surface O_3 over eastern China. This study revealed that the meteorological factors could explain ~46% of the daily variations of summer surface O_3. Particularly, synoptic factors contributed to ~37% of the overall effects associated with the meteorological factors. Furthermore, six predominant SWPs were identified by the self-organized map, and the results indicated a weak cyclone system and a southward prevailing wind inducing a positive O_3 anomalies over the eastern China.”.

9. Line 95-97, "The abovementioned indicates that the variation of meteorological factors, which are mainly driven by the evolution of different weather circulation situations, play a non-negligible role in air pollution. Therefore, classification of air pollution according to the meteorological circulation has become particularly important …" The abovementioned literatures cannot support this statement.

RESPONSE: Thank you for the comment. This statement has now been deleted in the revised manuscript.

10. Line 101-102, "In recent years, it has become possible to objectively classify atmospheric circulation conditions using weather data such as GH, sea level pressure…" It is not true. The objective classification method has been used since the 1990s.

RESPONSE: Thank you for pointing out the biased description. We have now revised it based on your suggestion (Lines 121-123 of page 5).

11. Line 104-105, "the objective approach has been widely used in air pollution research (Beck & Philipp, 2010)…" Beck and Philipp (2010) didn't study the pollution issues.

RESPONSE: We apologize to the inappropriate citation. This citation is now removed from our manuscript.

12. Line 115-118, "Many studies have suggested that PM2.5 and O3 pollution are mainly related to the East Asian summer monsoon (EASM) and western Pacific subtropical high (WPSH) (Li et al., 2018a; Xie et al., 2017; Yin et al., 2019; Zhao et al., 2010)." More detailed information about these previous studies can be given, their studied periods, temporal scale and spatial scale. Seasonal variation? Inter-annual variation? The paper of Xie et al. (2017) has been withdrawn, please check (https://acp.copernicus.org/preprints/acp-2017-500/).

RESPONSE: Thank you for your kind suggestion. We have revised the content as follow:

"Many studies have suggested a moderating effect of East Asian summer monsoon (EASM) and western Pacific subtropical high (WPSH) on air quality over China (Li et al., 2018; Yin et al., 2019; Zhao et al., 2010). In particular, Li et al. (2018) applied RegCM4-CHEM simulation to analyze the differences of ozone level among three strong and weak monsoon years, and found that the concentrations of O_3 over the central and eastern China were higher in strong EASM years than that in weak EASM years.".

13. Line 129-131, "the compound O3-PM2.5 pollution-related meteorological conditions, should be complex and likely to be associated with certain weather types". This statement is not well supported.

RESPONSE: Thank you for your suggestion. We have revised the content as follow: "Due to a variability of local meteorological conditions under the impacts of various synoptic weather types and modulation of large-scale WPSH movement, the causes and consequences of meteorological factors for the formation of compound O_3-$PM_{2.5}$ pollution could be complex.".