Response to Reviewer #1

Summary:

This paper uses a combination of observation and reanalysis data to investigate the possible impact of large-scale meteorological conditions on surface air quality (specifically ozone) in North China. Arctic sea ice concentrations in the spring are identified as a driver of the Eurasian teleconnection pattern which during the negative phase leads to meteorological conditions which are favorable to the photochemical production of ozone over North China.

While I find this may be a novel result, I find this study lacks substance that demonstrates to me that the authors fully understand how they have come to these conclusions. I recommend the manuscript undergoes major revisions to include more details.

Major Comments:

1. **The paper is very short compared to the number of figures included (6 Figures plus 12 in the supplement). It reads to me like a "Letters" type of paper (i.e., Geophysical Research Letters) where one has a new time-sensitive idea or maybe a Nature or Science paper, where the article itself is short but the detailed description of data/methods/etc are in a supplemental at the end. However, this manuscript is short and lacks the detailed description of the data and methods and discussing the results in the greater context of current literature as I would expect from an ACP article.**

Reply:

The manuscript has been revised according **to the ACP format**.

(1) In the revised version, the main texts of this article lengthened about **35%, i.e., from 220 lines to 290 lines.**

(2) The number of the Figures were **12** in the revised version, instead of 6 in the old version, in the main body.

(3) Both of the description of the data and methods and the discussion of the results were **rewritten and were recognized.**

Revision:

The revised manuscript without and with tracks were both uploaded for review.

2. **I found the Introduction section haphazard without a clear focus. Take the time to clearly outline and describe each idea. It jumps from ozone in China (Line 27) to European clean air laws (Line 28; could talk about US Clean Air act too) back to China (Line 30), to finally talking about how ozone is formed**

(Line 32), to how the NAO impacts European ozone(Line 34) to North American ozone and the jet stream position (Line 35-36), back to Asia (Line 36) and briefly mentions the Eurasia teleconnection pattern (line 41). Each one of these ideas could be and should be expanded on.

Reply:

According to the reviewer's suggestion, the introductions were **entirely revised and rewritten** now.

(1) the introduction of European clean air laws was confusing, and now was deleted. Thus, the introduction of the ozone polluted features f**ocused on those in China.**

(2) In the second paragraph of the introduction, the ideas how the climate anomalies (e.g., NAO, jet stream, west Pacific subtropical high and East Asia summer monsoon) were **expanded on**. The details can be found in the following revisions attached.

(3) Due to insufficient studies, related to how the climate anomalies impacted the ozone pollutions in China, some closely findings in North American were still introduced. Indeed, the findings, such as NAO-ozone in Europe and jet stream-ozone on North American, provided meaningful and substantial clues to our studies.

Revision:

…For example, the prevailing positive phase of the North Atlantic Oscillation contributed to the increasing ozone concentration in western and northern Europe, through the anomalous atmospheric circulations to influence regional photochemical processes (Christoudias et al., 2012; Pausata et al., 2012)…

…The summer surface O_3 variability in North America is significantly modulated by the position of the jet stream (Lin et al., 2014). Barnes and Fiore (2013) pointed out jet position may dynamically modulate surface ozone variability in eastern North America and other northern mid-latitude regions…

…A strong positive correlation between the East Asian summer monsoon and summer mean ozone existed. The model simulation by Yang et al. (2014) illustrated that the changes in meteorological parameters, associated with East Asian summer monsoon, lead to 2–5% interannual variations of surface O_3 concentrations over central eastern China. Focusing on the dataset in 2014, a significantly strong west Pacific subtropical high resulted in higher relative humidity, more clouds, more rainfall, less ultraviolet radiation and lower air temperatures, which were unfavourable for the formation of O_3 (Zhao and Wang, 2017)…

Revision with tracks were also posted:

~~There is rarely a direct discharge of s~~Surface O_3~~.~~ is a secondary pollutant. The precursors of O_3 (e.g. NOx and VOC) photochemically react to generate O_3 under suitable weather conditions, i.e., hot-day and sunny environments (An et al., 2009). ~~Sedimentation~~Surface deposition, dynamic transport and ~~attenuation~~ dispersion of O_3 are also closely related to atmospheric circulations. For example, ~~The North Atlantic Oscillation intercontinentally affects surface O_3 concentrations over Europe (Christoudias et al., 2012; Pausata et al., 2012)~~the prevailing positive phase of the North Atlantic Oscillation contributed to the increasing ozone concentration in western and northern Europe, through the anomalous atmospheric circulations to influence regional photochemical processes (Christoudias et al., 2012; Pausata et al., 2012). ~~.~~The summer surface O_3 variability in North America is significantly modulated by the position of the jet stream (~~Barnes and Fiore, 2013;~~ Lin et al., ~~2015~~2014). Barnes and Fiore (2013) pointed out jet position may dynamically modulate surface ozone variability in eastern North America and other northern mid-latitude regions. A strong positive correlation between the East Asian summer monsoon and summer mean ozone existed ~~during 1986–2006, based on numerical model results (Yang et al., 2014)~~. The model simulation by Yang et al. (2014) illustrated that the changes in meteorological parameters, associated with East Asian summer monsoon, lead to 2–5% interannual variations of surface O_3 concentrations over central eastern China. Focusing on the dataset in 2014, ~~A~~a significantly strong west Pacific subtropical high resulted in higher relative humidity, more clouds, more rainfall, less ultraviolet radiation and lower air temperatures, which were ~~unfavorable~~unfavourable for the formation of O_3 (Zhao and Wang, 2017). The photochemical reaction was the main local sources of O_3. The hot and dry environments and the violent solar radiation could accelerate the chemical conversion from the precursor to O_3 (An et al., 2009; Tong et al., 2017). In 2013, a severe heat wave~~,~~, with highest temperature 41.1 °C, contributed to the high O_3 concentration in the Yangtze River Delta (Pu et

3. **The Wang and He (2015) EU calculation was adapted from the EU pattern of Wallace and Gutzler (1981). Does the reason they adapted the equation apply for this project? Which calculation was used in the citations in the Introduction (line 42) versus in the Methods section (Line 73)? A full description in the introduction regarding the EU original teleconnection pattern and the characteristics of its positive and negative phases are not described or illustrated and this would be beneficial for the Section 4 and 5. Perhaps a useful reference would be Wang, N. & Zhang, Y. Clim Dyn (2015) 44: 1017. https://doi.org/10.1007/s00382-014-2171-z**

Reply:

(1) The reference, fully descripted the EU pattern in winter, substantially helped us to understand the impacts of EU in the Asian climate and was **detailedly introduced**.

(2) However, the season Wang and Zhang (2015) and Wallace and Gutzler (1981) concerned is winter.

(3) Wang and He (2015) regarded the **summer EU pattern** as the main reason for the severe summer drought in North China in 2014. Considering the **seasonal change** of the EU pattern's location, the calculation procedure for the EU index here was adapted from Wang and He (2015).

Revision:

…The EU pattern is a major teleconnection pattern in the Northern Hemisphere and appears in all seasons. **Wang and Zhang (2015)** used the method defined by Wallace and Gutzler (1981) to calculate the EU pattern index in winter and pointed out that the positive EU phase is associated with a cold-dry climate in East China, vice versa. Meanwhile, Wang and He (2015) regarded the summer EU pattern as the main reason for the severe summer drought in North China in 2014. Considering the seasonal change of the EU pattern's location, the calculation procedure for the EU index here was consistent with that in Wang and He (2015)…

Wang, N., Zhang, Y.: Evolution of Eurasian teleconnection pattern and its relationship to climate anomalies in China. Climate Dynamics, 44(3-4):1017-1028. 2015

4. **The first portion of the Results section refer to figures in the supplemental and are actually referred to before Figure 1 (Lines 79-100). Notes to the authors from ACP states "The supplement shall contain only complementary information but no scientific interpretations or findings/messages that would go beyond the contents of the manuscript." Consider including Figure S1 at least in the main body of the text. Figures S6, S7 and S8 are also referenced in the results sections as more than complementary analysis to the main findings and should be considered for the main text.**

Reply:

The Figure S1, S6, S7, S8 and S11 were **moved to the main text** in the revised version. Now, there were 12 Figures in the main text and 6 Figures in the supplemental information.

Revision:

The mentioned Figures were Figure 1, 3, 5, 8 and 11 in the revised manuscript.

5. **Of the figures in the main text, some improvements should be made in order for the reader to follow along with the results in Sections 4 and 5.**

5.1 In Figure 1g, h, which temperature is color and which is contoured?

Reply:

The negligence was revived. The SAT is with shading and the temperature at 200 hPa is contoured.

Revision:

Figure 2…(g–h) SAT (shading), and temperature at 200 hPa (contour)…

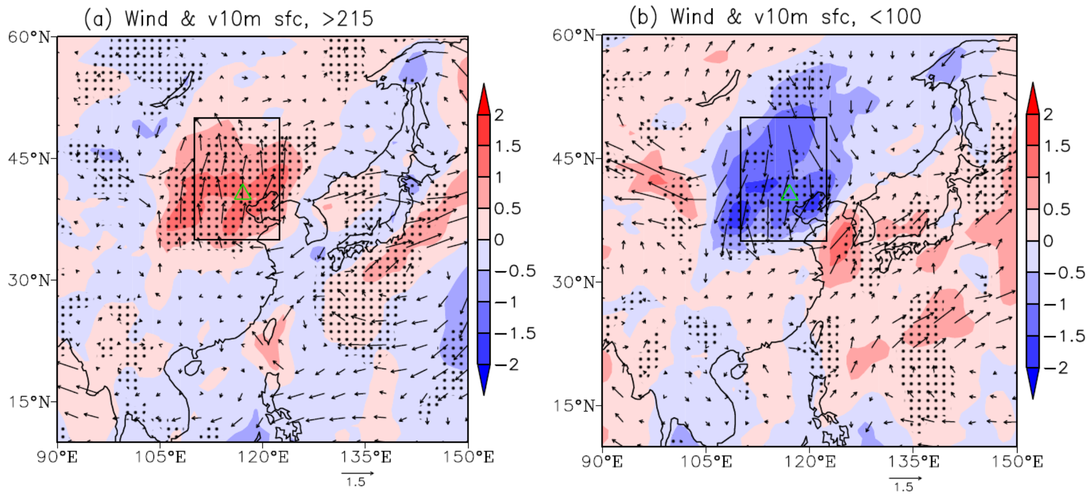
5.2 It is hard to see the Wind arrows in some of the plots (Figure 1a,b and Figure 4), consider rescaling or decluttering?

Reply:

The wind arrows were **enlarged**, i.e., rescaling and decluttering. The corresponding Figures in the supplementary information were also revised.

Revision:

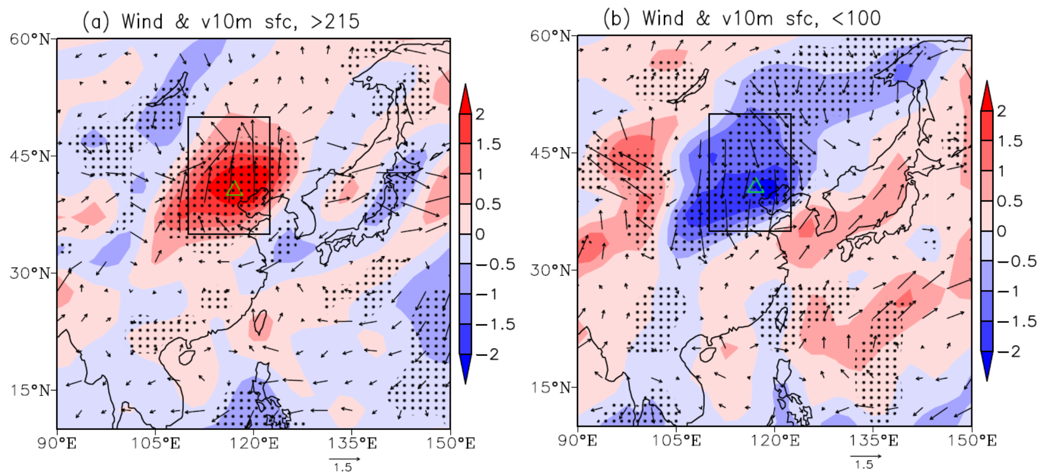
These composites were calculated using the ERA-Interim datasets…



…(a–b) surface wind (arrow) and v-wind (shading)…

…The green triangle in panel (a-b) illustrates the location of the Shangdianzi site…

These composites were calculated using the NCEP/NCAR datasets…



…(a–b) surface wind (arrow) and v-wind (shading)…

…The green triangle in panel (a-b) illustrates the location of the Shangdianzi site…

Figure 4 in the old version were revised and is Figure 7 now.

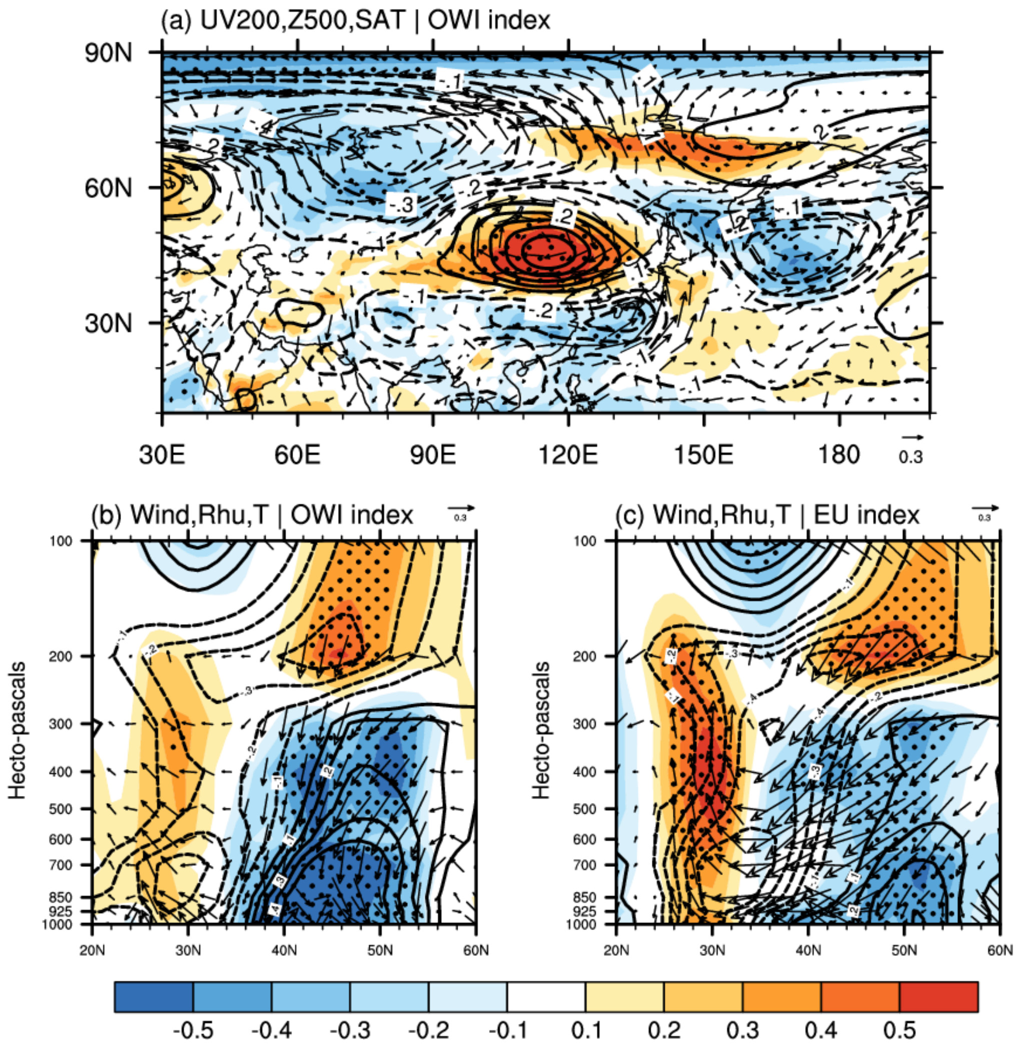


Figure 7. The associated atmospheric circulation. (a) The correlation coefficients between the JJA mean OWI and surface air temperature (shading), wind (arrow) at 200 hPa and geopotential height at 500 hPa (contour) from 1979 to 2017. The black dots indicate that the CC with surface air temperature was above the 95% confidence level. The cross-section (110 °–125 °E mean) correlation coefficients between JJA mean OWI (a), EU pattern index (b) and relative humidity (shading), temperature (contour), wind (arrow, vertical speed multiplied by 100) from 1979 to 2017. The black dots indicate that the CC with relative humidity exceeded the 95% confidence level (t test). The data used here are ERA-Interim datasets.

5.3 In the figure captions with the contours, it is not stated what are the contour intervals. In some of the supplemental figures the contours are labelled. Either label or define (e.g., is dashed for negative in Figure 4a?).

Reply:

The labels of the contours were added in the revised manuscript.

Revision:

Please see the above attached Figure 7 (i.e., Figure 4 in the former version).

The revised Figure S4 in the supplementary materials were also attached below.

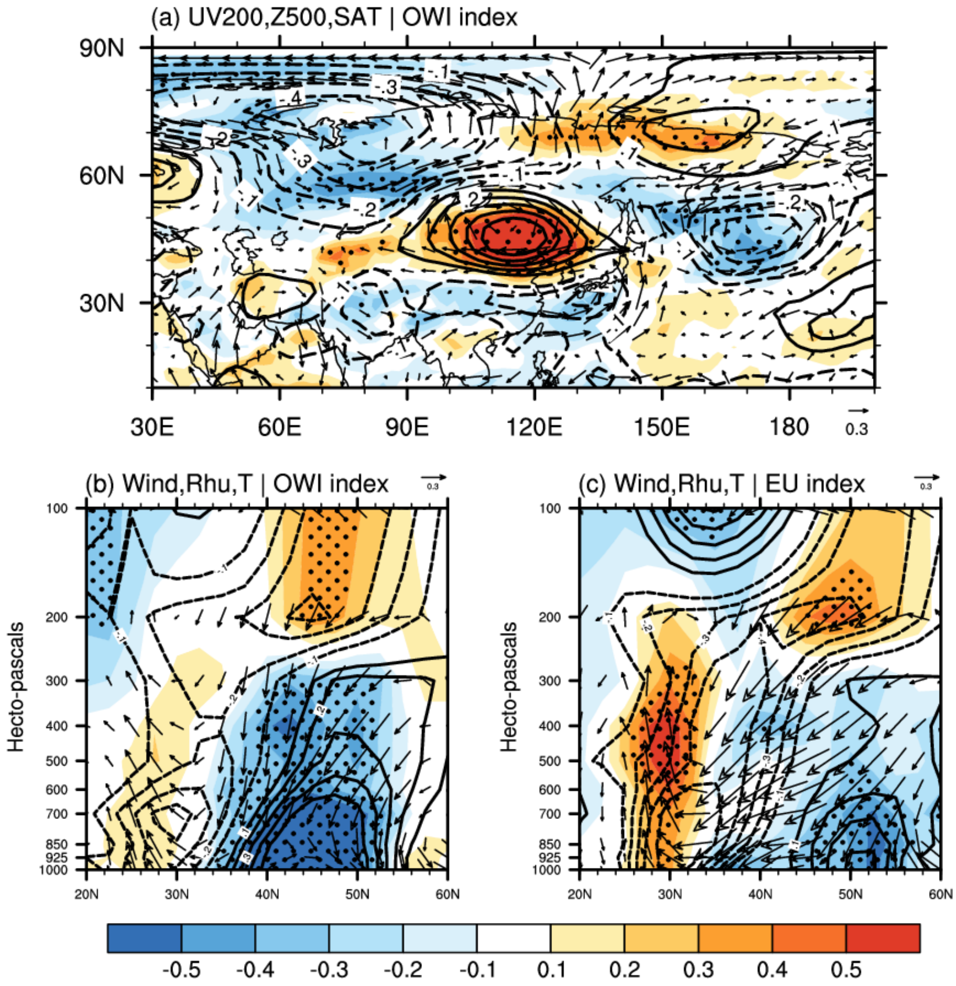


Figure S4. The associated atmospheric circulation. (a) The correlation coefficients between the JJA mean OWI and surface air temperature (shading), wind (arrow) at 200 hPa and geopotential height at 500 hPa (contour) from 1979 to 2017. The black dots indicate that the CC with surface air temperature was above the 95% confidence level. The cross-section (110°–125°E mean) correlation coefficients between JJA mean OWI (a), EUTP index (b) and relative humidity (shading), temperature (contour), wind (arrow, vertical speed multiplied by 100) from 1979 to 2017. The black dots indicate the CC with relative humidity exceeding the 95% confidence level (t test). The data used here are NOAA datasets.

5.4 Some of the figures are too small or the shading is too dark (saturated) or the presence of wind arrows makes it difficult to see the dotted significant areas (Figs 4, 5, 6c,d).

Reply:

The related Figures were re-plotted. The wind arrows were enlarged, the color bar of shading was improved, i.e., **the saturation is modified**.

Revision:

The revisions for Figure 4 can be found in the reply to Comments 5.2 and 5.3.

The revised Figure 9 (i.e., Figure 5 in the former version) and Figure 10 (i.e., Figure 6 in the former version) in the supplementary materials were also attached below.

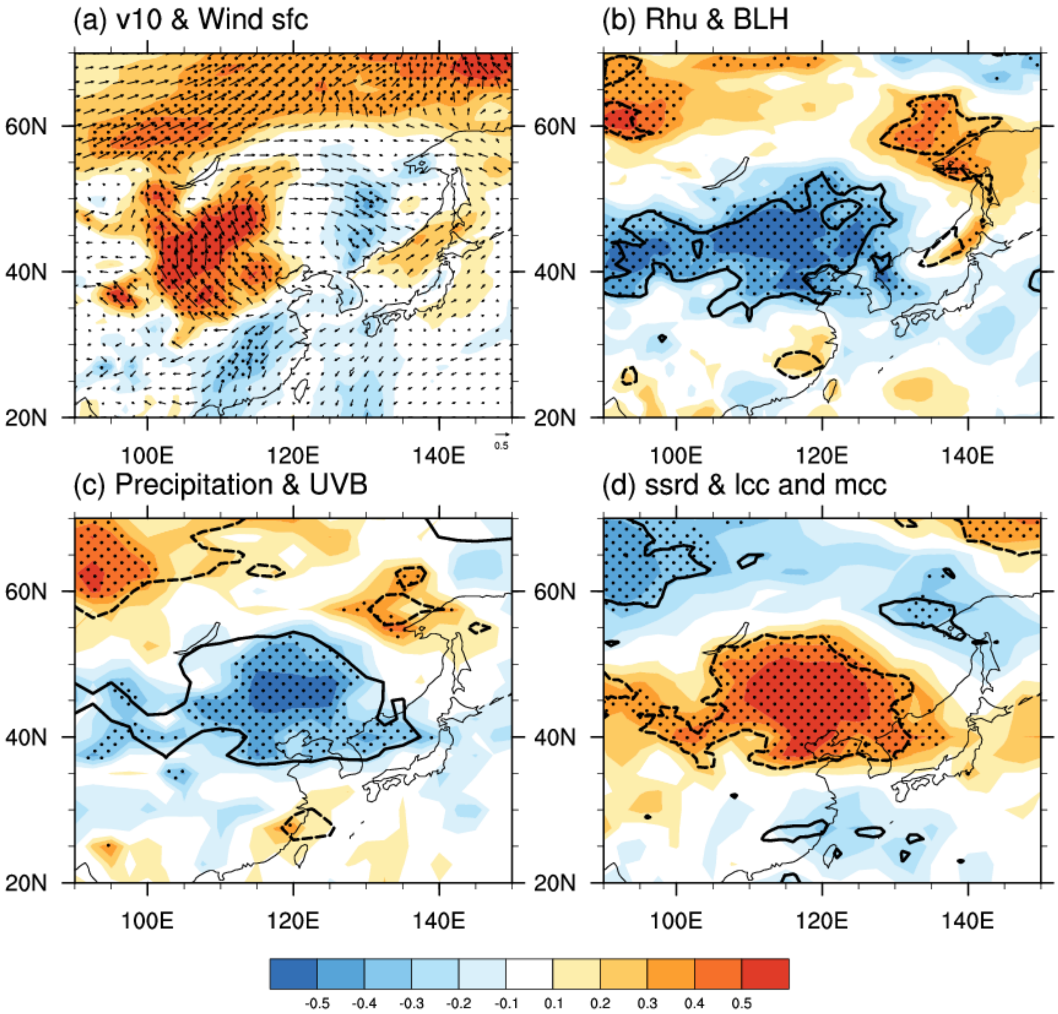


Figure 9. The associated meteorological conditions. (a) The correlation coefficients between the JJA mean OWI and v wind at 10 m (shading), surface wind (arrow), (b) relative humidity near the surface (shading), boundary layer height (contour), (c) precipitation (shading), downward UV radiation at the surface (contour), (d) downward solar radiation at the surface (shading), sum of low and medium cloud cover (contour) from 1979 to 2017. The black dots indicate that the CC with temperature was above the 95% confidence level. The contours plotted in panel (b–d) exceeded the 95% confidence level. The data used here are ERA-Interim datasets.

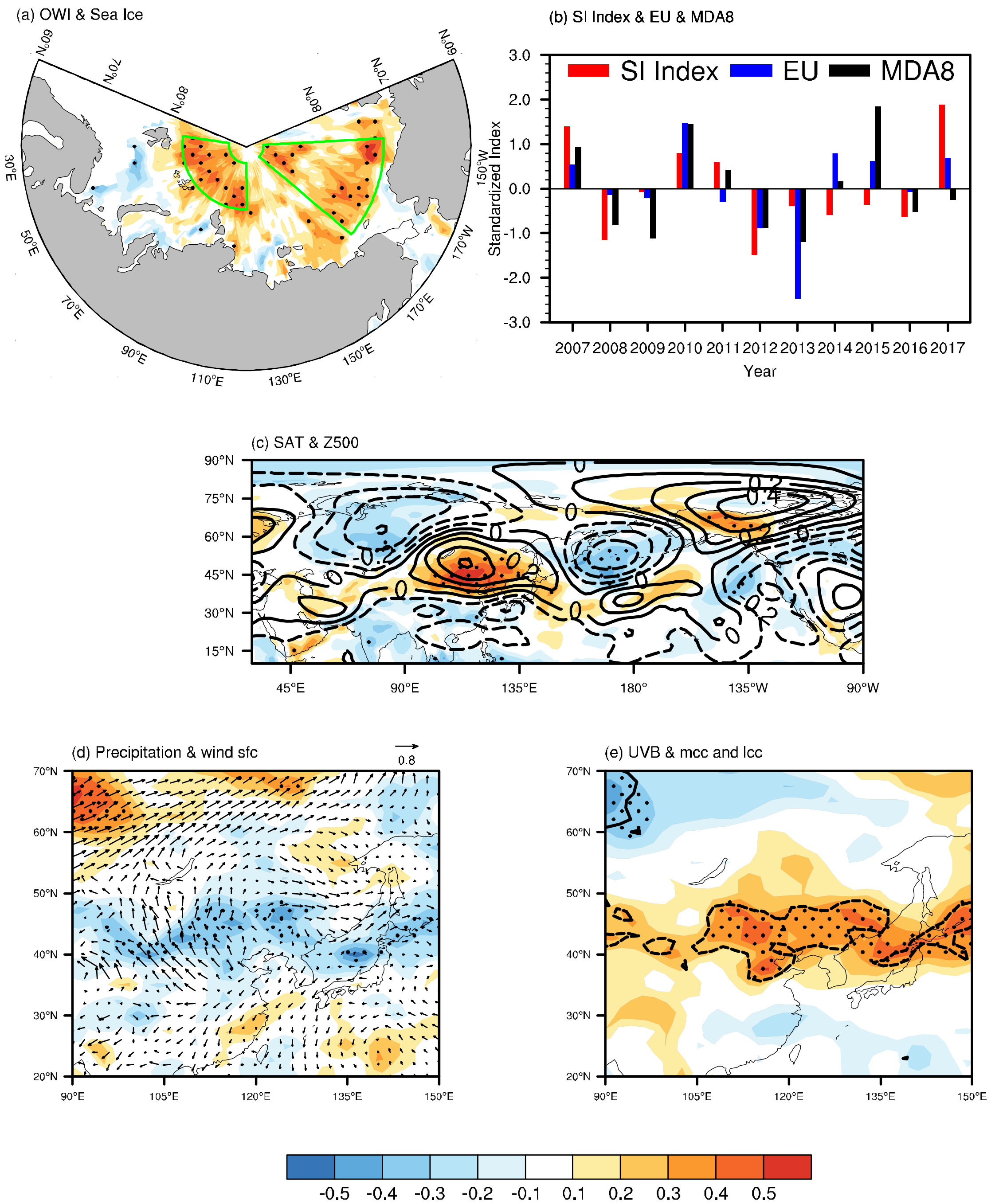


Figure 10. The role of the Arctic sea ice. (a) The correlation coefficients between the JJA mean OWI and May sea ice, (b) The variation of the May SI index (red bar, area-averaged sea ice of the green boxes in panel a), JJA mean EU pattern index (blue bar) and JJA mean observational SDZ MDA8 (black bar) from 2007 to 2017. (c) The correlation coefficients between the May SI index and surface air temperature (shading), geopotential height at 500 hPa (contour) from 1979 to 2017. The black dots indicate that the CC with surface air temperature was above the 95% confidence level. (d) The correlation coefficients between the May SI index and precipitation (shading), surface wind (arrow), (e) downward UV radiation at the surface (shading) and sum of low and medium cloud cover (contour) from 1979 to 2017. The black dots indicate that the shading CC with precipitation (d) and downward UV radiation (e) was above the 95% confidence level. The data used here are ERA-Interim datasets.

5.5 As for the supplemental, I do not understand the blue lines in Figure S2, and the labelling of the xaxis (does it start June 2006 or June 2007, the tick makes no sense with the figure caption).

Reply:

The data were JJA 2007, JJA 2008….Actually, they were not temporally continuous. Thus the blue lines were plotted to **separate the data in different years**.

The citation of Figure S1 was improved to include more explanation, as follows:

Revision:

Figure S1. The variation in the SDZ MDA8 from June to August during 2007–2017.**The blue lines were used to divide the data in different years. For example, the data on two sides of the first lines were belonged to JJA 2007 and JJA 2008, respectively.**

5.6 I also do not know how to read figure S3 (maybe a table would be better?). It looks to me like the histogram has been cut off and values well above 90 should be shown.

Reply:

According to the reviewer's advice, the Figure was **changed to Table S1**, which was much clearer to show the variation in the number of MOP and NOP.

Revision:

Table S1. The number of days with MOP and NOP events.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Mean
MOP	22	8	8	24	14	9	10	11	26	11	12	14
NOP	4	12	12	8	4	17	22	9	4	18	16	11.5

6. **Throughout the manuscript, both ERA-Interim and NCEP/NCAR reanalysis data (referred to as NOAA data in the paper, but more commonly referred to as NCEP/NCAR reanalysis) are used, with ERA-Interim being used as the main result and NCEP/NCAR reanalysis shown in the supplemental.**
   In a similar vein, it is said that Shangdianzi station (SDZ) is one of three regional background stations in China (Line 56); Is it possible to use the other two stations to test the OWI methods?

Reply:

(1) The expression of NOAA data has been **changed to the NCEP/NCAR** data throughout the MS.

(2) The other two regional background stations in China are Longfengshan in Heilongjiang province and Lin'an to the southwest of Shanghai, which are quite far away from the North China and are **uncorrelated to this study.** Furthermore, the

data from the regional background stations were not public, and we did not gain the data in the other stations.

Revision:

The daily mean and monthly mean ERA-Interim data were directly downloaded from the ERA-Interim websiteanalyzed in this study. Furthermore, the daily mean and monthly reanalysis datasets supported by the National Oceanic and Atmospheric Administration (NOAA) were also employed and denoted as NOAA NCEP/NCAR (National Center for Environmental Prediction and the National Center for Atmospheric Research) data. The 2.5°×2.5° geopotential height (Z), zonal and meridional wind, relative humidity, vertical velocity, air temperature at different pressure levels, SAT and wind, downward UV radiation, downward solar radiation, low and medium cloud cover were downloaded from the National Center for Environmental Prediction and the National Center for Atmospheric Research (Kalnay et al. 1996). The BLH of NCEP/NCAR dataset was only available from 1979 to 2014 in the NOAA data was derived fromthe website of the NOAA-CIRES 20th Century Reanalysis version 2c (Giese et al., 2016). The daily precipitation data was from the CPC global analysis of the daily precipitation dataset (Chen et al., 2008).

7. In Section 3, the boxed regions that are used for the OWI calculations are shown in Figure 1. Make a better connection between these boxed regions in the text to the respective figure and also state that SDZ is located within these boxes. This is why you are doing the correlation coefficient between the SDZ ozone concentrations to the meteorological fields within these boxes, right? The boxes look to fit the maximum correlation for the shaded composite fields and therefore are different sizes. Can the authors discuss more as to the methods which lead to these boxed regions?

Reply:

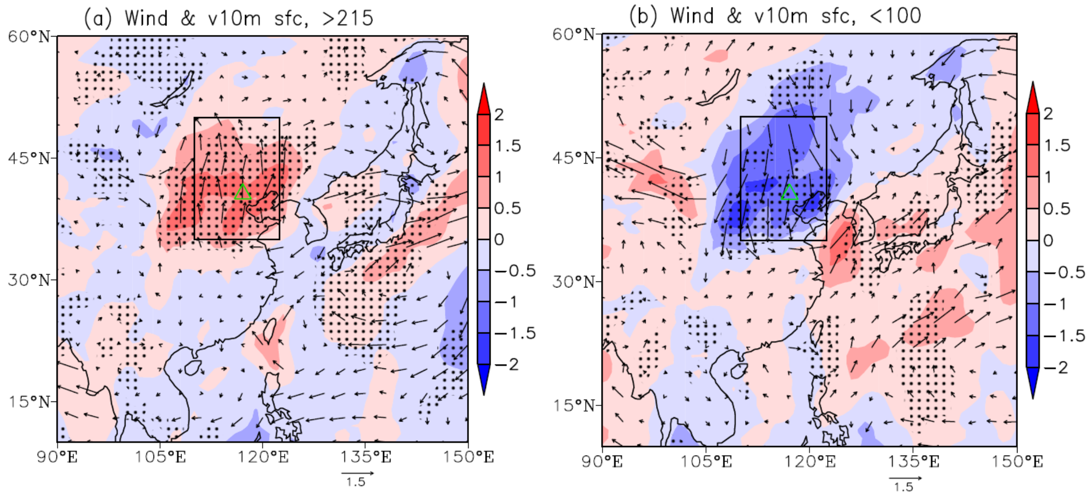
(1) The location of Shangdianzi station was also plotted in Figure 2, i.e., **the green triangle, to enhance the connection**.

(2) The process of calculate the meteorological index is added. The important point is the method to ensure the boxed region. Simply, **the averaging area for meteorological indexes were the regions with most significantly different elements** in the composites of MOP and NOP events. Because the box was chosen for each element, the boxes was a little different, but still near the North china.

Revision:

(1) …During calculating the correlation coefficients with the meteorological conditions, the averaging area for meteorological indexes were the regions with most significantly different elements in the composites of MOP and NOP events…

(2) …The green triangle in panel (a-b) illustrates the location of the Shangdianzi site…



8. **At the start of Section 4, the authors state "After 1979, the quality of the reanalysis data was improved to support studies of climate variability and change." This isn't quite true, the quality of reanalysis data improved for the period in the datasets after the assimilation of satellite data, which was made possible starting in 1979. The NCEP/NCAR reanalysis covers the period prior to the satellite era, therefore studies of climate variability and change must take into consideration the introduction of satellite data as well as subsequent changes in the observation system (introduction of new satellites and when satellites are no longer in operation). This needs to be properly addressed in the paper.**

Reply:

The original presentation was confusing and not accurate. According to the reviewer's suggestion, the error was revised.

Revision:

…After the assimilation of satellite data, possible in 1979, the quality of the reanalysis data was improved…

9. **In Section 5, only the month of May sea ice is discussed. Did the authors investigated other lag periods?**
   Is there literature that describes the interaction between sea ice concentrations and large-scale atmospheric circulation that can be referenced in this manuscript?

Reply:

(1) The other lag periods were also studied during our research. In the other months, i.e., **from December to April, the sea ice anomalies did not show closely connections**

with the JJA mean OWI (Figure R1). Related discussions were added in the revised manuscript.

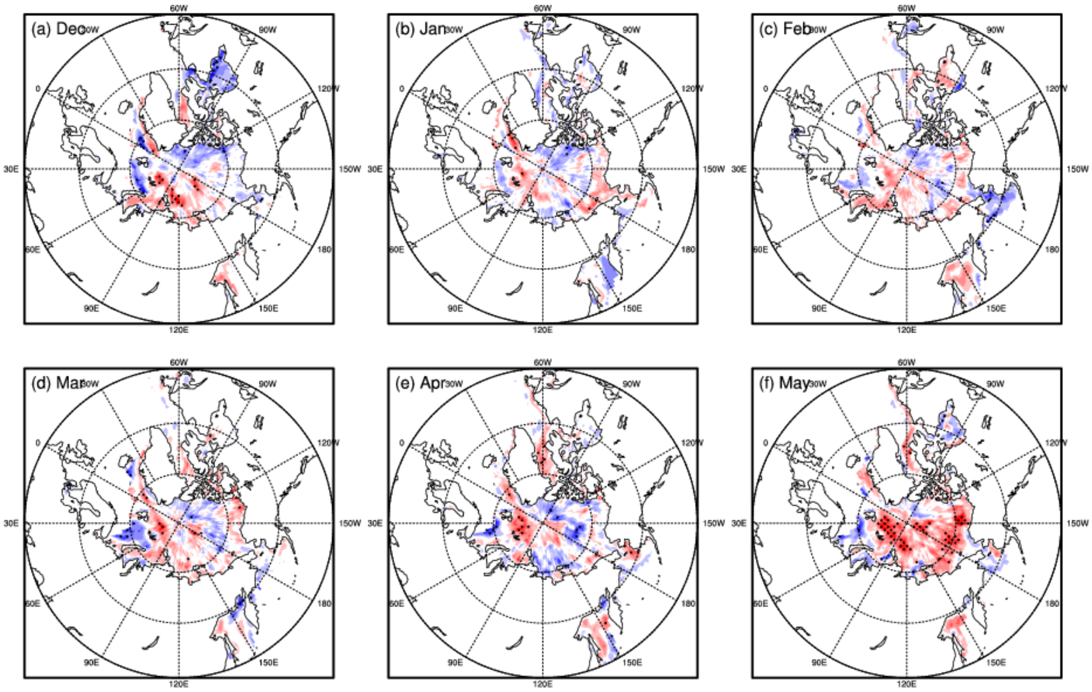


Figure R1. The correlation coefficients between the JJA mean OWI and December (a), January (b), February (c), March (d), April (e) and May (f) sea ice concentration.

(2) The literature that describes the interaction between sea ice concentrations and large-scale atmospheric circulation were referenced in the revised manuscript.

Revision:

(1) The correlation between the sea ice and JJA OWI was monthly checked (Figure omitted), and we found the interannual variation of OWI was significantly correlated with May sea ice conditions to the north of Eurasia, especially near the Gakkel Ridge, the Canada Basin and the Beaufort Sea (Figure 10a).

(2) The EU pattern originated from the Arctic region. The preceding sea ice anomalies could stimulate atmospheric responses like EU pattern in summer (Wang and He, 2015) Thus, the role of Arctic sea ice on the OWI was also explored in this study.

Minor Comments:

Line 26: smog is visible to humans and ozone is a key ingredient to smog.

Reply:

According to the reviewer’s advice, the discussion about the visibility was **deleted**.

Revision:

Due to drastic air pollution control in China since 2013, haze pollutions are being controlled in recent years (The environmental statistics unit of stat-centre in Peking University, 2018), appearing as sharp decreasing in fine particulate matter ($PM_{2.5}$). However, surface O_3 pollution, which always occurred on clear and sunny days (Wang et al., 2017), has not improved (Li et al., 2018).

(O_3) pollution in summer (Ma et al., 2016; Tang et al., 2018). Due to drastic air pollution control in China since 2013,~~the low visibility it caused and its obvious unusual smell,~~ haze pollution~~ easily causes warning and~~ are being controlled in recent years (The environmental statistics unit of stat-~~center~~centre in Pe~~r~~king University, 2018), appearing as sharp decreasing in fine particulate matter ($PM_{2.5}$). However, surface O_3 pollution, which~~has~~ always occurred on clear and sunny days (Wang et al., 2017), ~~so it is not visible to humans.~~ has not improved (Li et al., 2018). The negative effects of surface O_3 pollution was not

Line 27-28: Can you provide any references which have looked at ozone pollution in China linked to climate variability

Reply:

A reference was cited.

Revision:

… but the impacts of climate variability on surface O3 pollution in China (Yang et al, 2014) have not been sufficiently studied…

Line 28: 'benefitted' with two t's is the British spelling.

Line 28: Provide a reference and further details on the European 'rigorous air protection act' and what you mean by 'maintained good air quality' and in the same sentence 'ozone levels are increasing'.

Reply:

(1) According to the major comment 2, the introduction of European clean air laws was deleted.

(2) Thus, the word "benefitted" was concomitantly deleted.

Revision:

2017), ~~so it is not visible to humans.~~ has not improved (Li et al., 2018). The negative effects of surface O_3 pollution was not weaker than those of haze (Liu et al., 2018), but ~~T~~the impacts of climate variability ~~features and causes of~~ on surface O_3 pollution in China~~, especially~~ (Yang et al, 2014) ~~the impacts of climate variability,~~ have not been sufficiently studied. ~~Europe has benefitted from its rigorous air protection act and maintained good air quality, but the surface ozone levels still showed significant increases during 1995–2012 (Yan et al., 2017). In the major urban areas in China, the surface O_3 concentrations~~

Line 30: is the ambient air quality standard set by China or the World Health Organization? Please define and reference.

Reply:

The information has been added in the text. It is the standard in China.

Revision:

…the surface O_3 concentrations exceeded the ambient air quality standard of China (i.e., 100 μg/m³) by 100–200 % (Wang et al., 2017)…

Line 31: Can you define North China, or indicate it on a map? It is confusing as on Line 93 it is written 'in the north of China, especially in North China".

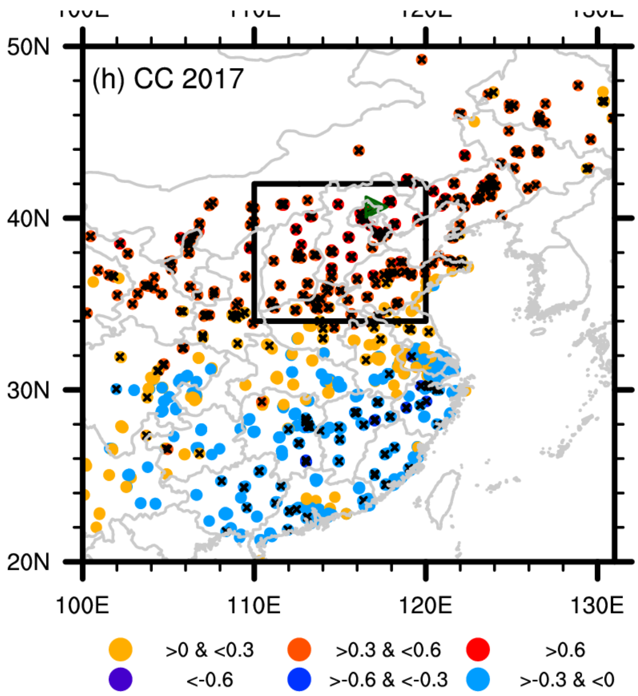
Reply:

(1) According to the reviewer's advice, the range of North China was plotted in Figure 1h and 5d.

(2) Line 93 was rewritten.

Revision:

…The distribution of correlation coefficients is similar to the MDA8 on Figure 1 (a, c, e, g). The SDZ MDA8 significantly covaried with the MDA8 in North China in summer…



The black box in panel h is the range of North China.

Line 32: What do you mean by discharge?

Reply:

It should be emission. According to the other reviewer's advice, this sentence was modified to "Surface O_3 is a secondary pollutant".

Revision:

Surface O_3 is a secondary pollutant…

Line 33: Describe the suitable weather conditions here, versus later in Lines 38-39 describing in detail the unfavorable weather conditions for ozone formation.

Reply:

The suitable and unfavorable weather were explained in the revised MS.

Revision:

…The precursors of O_3 (e.g. NOx and VOC) photochemically react to generate O_3 under suitable weather conditions, i.e., hot-day and sunny environments (An et al., 2009)…

…Focusing on the dataset in 2014, a significantly strong west Pacific subtropical high resulted in higher relative humidity, more clouds, more rainfall, less ultraviolet radiation and lower air temperatures, which were unfavourable for the formation of O_3 (Zhao and Wang, 2017)…

Line 41: Is it more common in the literature to refer to this teleconnection pattern simply as EU? In some of the figures EU is used. Commit to either using EU throughout or EUTP throughout the manuscript and figures.

Reply:

The abbreviation of Eurasia teleconnection pattern was **unified as EU** throughout the manuscript and figures.

Revision:

was constructed, which extends the study period to the historical period before 2007 and the projected future. Here, we show that in addition to anthropogenic emissions, the Eurasia teleconnection pattern (EUTPEU), a major globally significant atmospheric teleconnection pattern, influences surface O_3 pollution in North China on a time scale of climate. The local meteorological conditions associated with the EUTPEU pattern positive phase supported intense and efficient photochemical reactions to produce more surface O_3. The associated southerlies over North China transported surrounding O_3 precursors to superpose local emissions. Increased Ssolar radiation and high temperature during the positive EU phase dramatically enhanced O_3 photochemical reactionsproduction. Furthermore, due to the close connection between the preceding May Arctic sea ice and summer EUTPEU pattern, approximately 60% of the interannual variability of summer surface O_3 pollution was

Line 45: Can you list any more recent studies?

Reply:

More recent studies were listed, such as Zhu and Liao (2016) and Gaudel et al., (2018).

Revision:

Due to the close relationship between surface O_3 and meteorological conditions, the impacts of climate change on O_3 have been projected by various numerical models (Doherty et al., 2013; Melkonyan and Wagner, 2013; **Zhu and Liao, 2016; Gaudel et al., 2018**).

Line 45: Why talk about eastern China when the paper is interested in North China. Are there references that look at future ozone in North China?

Reply:

(1) North China was **a part of e**astern China.

(2) Related studies concentrated in North China were quite few, thus we talked about the findings in eastern China. Although these researches were done for the larger region, i.e., eastern China, some findings were be appropriate for the ozone pollution in North China. The cited papers actually provided clues to us.

Line 47: Which "previous studies" are you referring to?

Reply:

Related reference was cited here.

Revision:

…However, previous studies mainly focused on observational analyses of several synoptic processes (e.g., Zhao and Wang, 2017), rather than long-term climate diagnostics, because of the lack of long-term surface O_3 observations…

Line 54-58: Is this ozone data publicly available?

Reply:

The ozone data from 2014 to 2017 were publicly available in the website of the Ministry of Environmental Protection of China.

Line 58: What is special about the MDA8 calculation of the Technical Regulation on Ambient Air Quality Index that it required referencing it?

Reply:

The MDA8 was the maximum of the **running 8 h mean** O_3 concentrations during 24 hours in the day.

The explanation was supplemented in the revised manuscript.

Revision:

…The MDA8 was calculated as the maximum of the running 8 h mean O_3 concentrations during 24 hours in the day…

Line 62: What is the native resolution of ERA-Interim? Did you download the data to this resolution or regrid it? Did you download it originally at the 6-hour resolution and then created daily and monthly datasets?

Reply:

The resolution of ERA-Interim here is 1 °×1 °.

The daily mean and monthly mean datasets were directly downloaded and used in the manuscript.

Revision:

…The 1 °×1 ° ERA-Interim data used here included … The daily mean and monthly mean ERA-Interim data were directly downloaded from the ERA-Interim website in this study…

Line 69-70: As stated above, this reanalysis is more commonly referred to as NCEP/NCAR reanalysis.

Reply:

The expression of NOAA data has been changed to the NCEP/NCAR data.

Revision:

The daily mean and monthly mean ERA-Interim data were directly downloaded from the ERA-Interim websiteanalyzed in this study. Furthermore, the daily mean and monthly reanalysis datasets supported by the National Oceanic and Atmospheric Administration (NOAA) were also employed and denoted as NOAA NCEP/NCAR (National Center for Environmental Prediction and the National Center for Atmospheric Research) data. The 2.5°×2.5° geopotential height (Z), zonal and meridional wind, relative humidity, vertical velocity, air temperature at different pressure levels, SAT and wind, downward UV radiation, downward solar radiation, low and medium cloud cover were downloaded from the National Center for Environmental Prediction and the National Center for Atmospheric Research (Kalnay et al. 1996). The BLH of NCEP/NCAR dataset was only available from 1979 to 2014 in the NOAA data was derived fromthe website of the NOAA-CIRES 20th Century Reanalysis version 2c (Giese et al., 2016). The daily precipitation data was from the CPC global analysis of the daily precipitation dataset (Chen et al., 2008).

Line 73: Correct Wang et al to Wang and He.

Reply:

The errors were corrected.

Revision:

…the calculation procedure for the EU index here was consistent with that in Wang and He (2015)…

Line 80: Is it possible to label on a map these three regions?

Reply:

We tried to label these three regions on a map, but the Figure became unclear. To keep the meaning of the sentence and avoid confusion, we finally deleted these three regions.

Revision:

…During 2006–2014, O3 concentrations were only observed in the most developed regions in China…

Line 82: What is meant by "which appeared to be bordered by the Yangtze River".

Reply:

This sentence was confusing, and was improved as follows:

Revision:

…O_3 concentrations in the high-mid latitudes were higher than those in the lower latitudes, which appeared to be **separated** by the Yangtze River…

Line 82: 'rather high' is subjective. Change to be more qualitative.

Reply:

This sentence was confusing, and was improved as follows:

Revision:

…The O_3 concentrations in North China were already high in 2014;…

Line 86: Who's threshold?

Reply:

It is the threshold of the server surface O_3 pollution in China.

Revision:

…The observations, with maximum MDA8 higher than 265 μg/m^3 (i.e., the threshold of the server surface O_3 pollution in China)…

Line 89: State that SDZ is labelled on Figure S1a (though really should be in S1b logically since right hand panel compares to SDZ).

Reply:

The location of **SDZ is labelled on panels** b, d, f, and h in Figure 1 now.

Revision:

The green triangle in panels b, d, f, and h illustrate the location of the SDZ station.

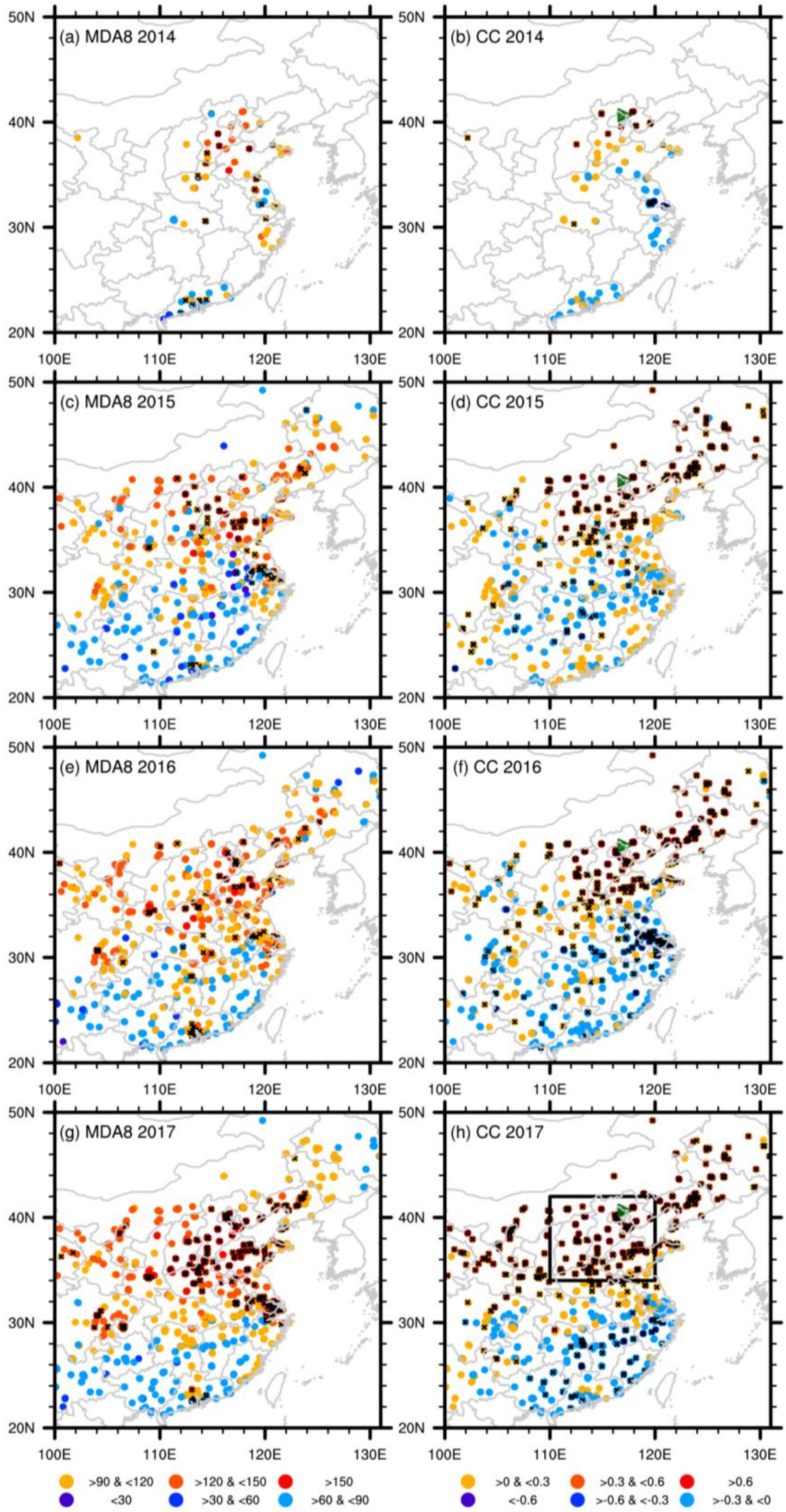


Figure 1. The distribution of the JJA mean MDA8 (a, c, e, g) and the correlation coefficients (b, d, f, h) between the daily MDA8 and SDZ MDA8 from 2014 to 2017. The black cross in panels a, c, e, and g indicate that the maximum daily MDA8 was larger than 265 μg/m³. The black cross in panels b, d, f, and

h indicate that the CC was above the 95% confidence level. The green triangle in panels b, d, f, and h illustrate the location of the SDZ station. The black box in panel h is the range of North China.

Line 92: There are a few instances where the degree symbol is not superscript in the manuscript.

Reply:

The similar errors were corrected throughout the manuscript.

Line 94: How can there be a diurnal difference in a maximum daily average? This sentence makes no sense to me.

Reply:

The errors were corrected. It should be **daily difference**.

Revision:

The daily difference in MDA8 was large, which contradicts the quasi-constant emission of ozone precursors.

Line 97: Can you switch the order, introducing NOP before MOP.

Reply:

According to the reviewer's advice, the orders were switched.

Revision:

…the thresholds of non-surface O_3 polluted level (NOP) and moderate surface O_3 polluted level (MOP) are 100 μg/m³ and 215 μg/m³, respectively…

Line 99: The mean number of MOP days is not explicitly shown in FigureS3.

Reply:

Replied in comment 5.6, the Figure was changed to Table S1 and the mean number of the MOP and NOP days were also listed.

Revision:

Table S1. The number of days with MOP and NOP events.

	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Mean**
MOP	22	8	8	24	14	9	10	11	26	11	12	14
NOP	4	12	12	8	4	17	22	9	4	18	16	11.5

Line 100: significant at what level? If this is from a figure in the supplement, consider moving that figure out of the supplement.

Reply:

The interannual variation in MOP (NOP) days was significant at the 95% confidence level, which was verified by t-test.

Revision:

…The interannual variation in MOP (NOP) days was significant at the 95% confidence level, without an obvious long-term trend…

Line 103: use SAT instead of spelling it out and introduce why cooler temperature in the high troposphere (T200) is favorable for surface ozone pollution (mentioned later in Line 117).

Reply:

(1) the abbreviation, i.e., SAT, was used.

(2) According to the other reviewer's suggestion (attached below), the discussion about the reason, why cooler temperature in the high troposphere (T200) is favorable for surface ozone pollution, was deleted.

> Line 116-117: The temperature of the upper troposphere is much more dynamicallythan radiatively-influenced at synoptic timescales (i.e. through tropopause height variations). This sentence should be removed.↵

Because we cannot perfectly address it now, the question was leave as an open question in the "Conclusion and Discussion" section.

Revision:

…The processes how the weather conditions impacted the photochemical reaction were not deeply discussed here and have been analyzed in many previous studies by the atmospheric chemists. **However, the reason why the cooler high troposphere contributed to the surface ozone pollution was still an open question and needed further attention**…

Line 121: what is downwash

Reply:

The downwash was confusing and was changed to "entrainment…… into the boundary layer".

Revision:

…The **entrainment of atmospheric ozone from the upper air into the boundary layer** enlarged the surface O3 concentration (An et al., 2009)…

Line 126: Why is Figure S5 included in the supplement

Reply:

All of the results from the NCEP/NCAR datasets were included in the supplementary information. The identical results were Figure 2 c, d by the ERA-Interim data.

Line 130: Any time MDA8 is used, is the reader expecting it to be the SDZ MDA8 unless otherwise stated? Make that clear earlier on in the text.

Reply:

The negligence were corrected throughout the manuscript. The MDA8 in SDZ station was denoted as **SDZ MDA8**, comparing to the **MDA8 in the other sites**.

Revision:

2017). The correlation coefficients between SDZ MDA8 and the observed MDA8 at the other sites were calculated and are shown in Figure 1 (b, d, f, h). The distribution of correlation coefficients is similar to the MDA8 on Figure 1 (a, c, e, g). The SDZ MDA8 significantly covaried with the MDA8 in North China in summer. Along with the increasing of the surface O_3 pollution, the covariation and the representativeness of SDZ MDA8 to the MDA8 in North China was strengthened. However,

Line 137: Reference Figure S7b-d. 'in North China (Figure S7b-d)'

Reply:

The related Figure, i.e., Figure 5, was referred now.

Revision:

…The significantly positive correlations were distributed in North China (Figure 5 b-d)…

Line 143-144: remind the reader that SDZ data began in 2006. This sentence is not clear to me.

Reply:

The confusing expression was corrected as follows:

Revision:

…During 2007–2017, the constructed JJA (June-July-August) mean OWI varied similarly with the observed MDA8 and captured the extremes (Figure 6). **Although the range of the SDZ MDA8 was 2006–2017, in the above OWI construction processes, only the data from 2007 to 2017 were used.** Thus, the datasets in 2006 were independent samples, and could verify the performance of the OWI…

Line 145: What do you mean by a staged minimum?

Reply:

The presentation was not clear. Actually, the value in 2006 was the minimum. This sentence was modified.

Revision:

…The JJA mean OWI in 2006 successfully reflected the variation in observed MDA8; even the MDA8 in 2006 was the minimum…

Line 148: Significant to what test and level?

Reply:

This sentence was modified.

Revision:

…Before the mid-1990s, the OWI was below zero, with a slightly decreasing trend and insignificant interannual variation. Since then, the OWI has increased…

Line 150: provide a reference for the sentence ending '….due to the steady economic development in China"

Reply:

A related reference was provided.

Revision:

…The emissions of O3 precursors increased persistently and linearly due to the steady economic development in China (Wang 2017)…

Response to Reviewer #2

Summary and General Comments:

1. This study attempts to link surface O3 from a site in North China to May Arctic sea ice extent and the Eurasia Teleconnection Pattern (EUTP), which amounts to a total of three degrees of separation (May Sea Ice -> Eurasia Teleconnection Pattern -> Ozone Weather Index (OWI) -> MDA8 O3 at the SDZ site).

1.1 The main results of the paper seem a bit overstated because of this leap. The authors show some nice analyses linking each of these factors to one another, but the point of this paper is to show skill in predicting summer average MDA8 O3 from EUTP and May Arctic sea ice. I am not convinced the authors were so successful in that regard. For example, on Figure 6b, the association with the Sea Ice Index and MDA8 is weak at best (see 2009, 2014, 2015, and 2017), and only 11 years of JJA O3 data from a single site are used to make these claims. The authors state in the abstract that May sea ice extent explains 60% of the interannual variability in summer surface O3, but that is actually the relationship that they found between sea ice and the OWI (Lines 188-190), which has its own separate, imperfect, relationship with MDA8 O3 levels at one specific site.

Reply:

(1) Possibly, our presentation was confusing. The goal of this study **was not prediction** of summer average O_3 MDA8. When we mentioned the predictions, we just emphasized the importance of our study to seasonal O_3 prediction. Furthermore, our studies, based on long-term meteorological data, **could support scientific basis and improve the potential of prediction**. This is the further meaning of our finding.

To avoid the confusing and the overstated problem, the words like "seasonal prediction" were modified or deleted.

The goal of this study was to reveal the **climatic connections** among Arctic sea ice, EU pattern, and surface ozone pollution. To enhance the theme, the title was also revised as "Arctic sea ice, Eurasia teleconnection pattern and summer surface ozone pollution in North China***: in terms of climate variability***".

(2) Another overstated expression, i.e., making OWI≈surface O3 pollution, was also corrected throughout the manuscript. In the Discussion, we also mentioned it as "**the OWI was still a substitution focusing on the impacts of the weather conditions**" and "Thus, the results in this study **concentrated on and emphasized the meteorological and climate factors**".

(3) Lines 188-190: the related Figure S11 was moved to the main text, i.e., Figure 11. This Figure 11 was to show the contribution of May sea ice, and **was not related to the seasonal prediction**. Although the generalized additive model could introduce linear and nonlinear relationships, the red line was fitted from historical May sea ice index and did not include any prediction.

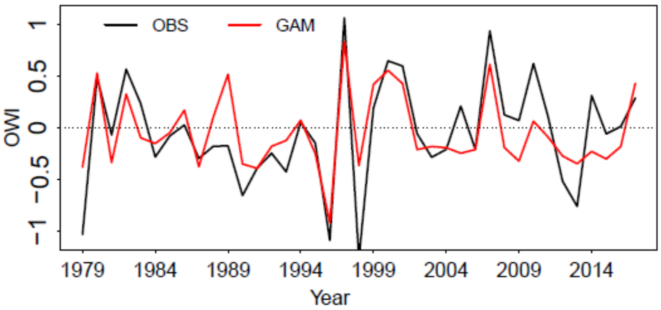


Figure 11. The variation in the observational OWI (black) and the fitted OWI by the generalized additive model (red) from 1979 to 2017

Revision:

The seasonal prediction was deleted, as follows:

attributed to Arctic sea ice to the north of Eurasia. This finding will aid~~s~~ in understanding the interannual variation of O3 pollution, specially the related meteorological conditions.~~the seasonal prediction of O_3 pollution.~~

effective driver, ~~were~~ was also ~~analyzed~~analysed. The outcomes of our research, in term of climate variability, may provide a basis for understanding the interannual variation of O_3 pollution, specially the related meteorological conditions. ~~and its seasonal to interannual prediction.~~

The analysis focused on the O_3-related weather conditions, such as……

…Furthermore, due to the close connection between the preceding May Arctic sea ice and summer EU pattern, approximately 60% of the interannual variability of **O_3-related weather conditions** was attributed to Arctic sea ice to the north of Eurasia…

…This finding will aids in understanding the interannual variation of O_3 pollution, **specially the related meteorological conditions**…

"the linear and nonlinear relationships were both introduced using the generalized additive model (Figure 11), and the contribution of May sea ice to the interannual variability of **OWI** was approximately 60%."

…In order to extend the time range of this study, the OWI was constructed in North

China. Although the feasibility of the construction approach was strictly examined, **the OWI was still a substitution focusing on the impacts of the weather conditions**. When discussing the impacts of atmospheric circulations, the linear trend was removed to weaken the signal of anthropogenic emissions. Thus, **the results in this study concentrated on and emphasized the meteorological and climate factors**. However, there is no doubt that the polluted emissions are the fundamental inducement of the surface O3 pollution…

1.2 In general, I found the statistical analysis and OWI formulation in the first half of the paper to be more enlightening than the second half. Perhaps a more careful discussion on EUTP and the sea ice effect will lead to a more convincing paper - Sections 4 and 5 are barely two pages of double-spaced text.

Reply:

(1) In the revised version, the section 4&5 lengthened about 50**%, i.e., from 60 lines to 90 lines.** The number of the Figures were **7** in the revised version, instead of 4 in the old version, in the main body.

(2) What's more important is the causality between May sea ice and OWI was verified by **a new numerical experiment by CAM5**. The proposed relationship and physical mechanisms were **reproduced by the well-designed experiment** (Figure 12). The details can be found the attached revised texts.

Revision:

The causality, i.e., the preceding May sea ice anomalies contributed to the subsequent JJA OWI in North China, was also confirmed by CAM5. During the control experiment (CTRL), the CAM5 model firstly integrated 20 years with climate mean initial and boundary conditions, and then, integrated 10 years with each 1st September of the last 5 years (i.e., five slightly different initial conditions). The JJA mean results of the last 6 years (i.e., 6 years × 5 groups = 30 ensembles) were employed as the output of the CTRL. On the basis of CTRL, the May sea ice concentration in the two boxes of Figure 10a was separately reduced by 10% (denoted as LowASI experiments), i.e., totally 30 sensitive runs. Similarly, the JJA mean results of 30 sensitive ensembles were employed as the output of the LowASI. The differences (LowASI minus CTRL) were the responses of atmospheric circulations and meteorological conditions to the declining May sea ice.

It was evident that an EU-like Rossby wave train was induced on the mid-troposphere

(Figure 12a), which propagated from the Taymyr Peninsula (–), Northeast China (+), to east of China and the west Pacific (+). Under such large-scale atmospheric anomalies, the anomalies of relative humidity were significantly positive and resulted in denser low and cloud cover in North China (Figure 12d). Furthermore, the cover of cloud efficiently prevented the solar radiation from reaching the land surface, meanwhile, cooled the air in the boundary layer (Figure 12b). Without hot-dry air and violent sunshine, the photochemical reaction was significantly decelerated and the generation of surface O_3 was rather weak. On the other side, sufficient moisture and clouds caused more rainfall (Figure 12c). The wet deposition effect was also significantly enhanced. Thus, corresponding to less Arctic sea ice in May, the photochemical process to generate O_3 was weakened, but the wet deposition effect to decrease O_3 was enhanced. That is, the positive relationship and associated physical mechanisms were causally verified.

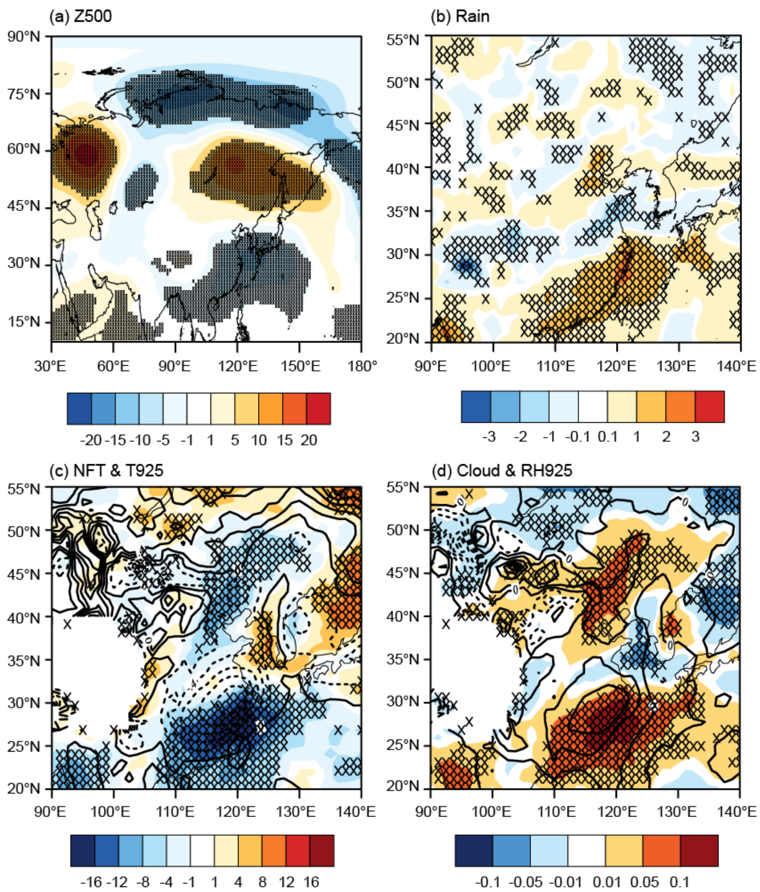


Figure 12. Composite results of the LowASI experiments (LowASI minus Ctrl) by the CAM5 model: (a) geopotential height at 500 hPa, (b) preciptation, (c) net radiative flux at the top of the atmosphere (shading) and temperature at 925 hPa (contour), and (d) sum of low and medium cloud fraction (shading) and relative humidity at 925 hPa (contour). The black hatching denotes the differences with shading were above the 95% confidence level (t-test).

2. There is a wealth of information buried in the Supplemental Figures, which is often frustrating to a lot of readers. Figures S1 and S6 in particular receive a lot of attention in the text, and therefore should be included as regular figures. Figure S11 is of great importance to the result stated in the second last sentence of the abstract (though I have separate issues with it as I mention above). Several of the Supplemental Figures should be moved to the main paper.

Reply:

(1) The Figure S1, S6, S7, S8 and S11 were **moved to the main text** in the revised version. Now, there were 12 Figures in the main text and 6 Figures in the supplemental information.

(2) In the revised version, the main texts of this article lengthened about **35%, i.e., from 220 lines to 290 lines.**

(3) The number of the Figures were **12** in the revised version, instead of 6 in the old version, in the main body.

(4) Both of the description of the data and methods and the discussion of the results were **rewritten and were recognized.**

Revision:

The mentioned Figures were Figure 1, 3, 5, 8 and 11 in the revised manuscript.

3. What is the motivation behind analyzing NCEP/NCAR Reanalyses in addition to ERA-Interim? This adds unnecessary supplementary figures and text. You can simply state in the text that a sensitivity test was performed with NCEP/NCAR reanalysis, which yielded very similar results (this should be expected).

Reply:

(1) The motivation to include the results of two popular Reanalysis data is to show the diagnostic results were **independent of the kinds of data**. In addition, to use two kinds of data could, in some extent, **decreases the uncertainties**.

In the manuscript, we clarify the mentioned motivation, such as “the analyses and conclusions were independent of data sets”.

(2) Our research filed is a bit **interdisciplinary**, and sometime, we received the reviewer’s comments that asked us to add contrastive results both from the ERA and NCEP/NCAR dataset. Thus, in the supplementary information of this manuscript, we directly submit them.

Revision:

... The above independent verifications proved that the performance of the summer OWI did not depend on the kinds of reanalysis data,…

…the impacts of the atmospheric circulations were confirmed by both the ERA-Interim and NCEP/NACAR data, i.e., the analyse and conclusions were independent of data sets….

Recommendation:

4. In its current form, this paper is not yet suitable for publication in ACP. I am suggesting major revisions that include *(1)* reorganization of Figures, and substantial edits to the text, *(2)* mainly in the Introduction and *(3)* Sections 4 and 5. I think that the paper discussion should remain focused on the meteorological relationships found linking the teleconnection patterns and surface O3 (which are interesting and useful to quantify!), and *(4)* less on claims of seasonal predictability that may not be warranted by the current study.

Reply:

The manuscript has been revised according **to the ACP format**. The title was also revised as "**Arctic sea ice, Eurasia teleconnection pattern and summer surface ozone pollution in North China: <u>in terms of climate variability</u>**"

(1) In the revised version, the main texts of this article lengthened about **35%, i.e., from 220 lines to 290 lines.** The number of the Figures were **12** in the revised version, instead of 6 in the old version, in the main body.

(2) The **introductions were entirely revised and rewritten** now. ①The introduction of European clean air laws was confusing, and now was deleted. Thus, the introduction of the ozone polluted features f**ocused on those in China.** ② In the second paragraph of the introduction, the ideas how the climate anomalies (e.g., NAO, jet stream, west Pacific subtropical high and East Asia summer monsoon) were **expanded on**. The details can be found in the following revisions attached. ③ Due to insufficient studies, related to how the climate anomalies impacted the ozone pollutions in China, some closely findings in North American were still introduced. Indeed, the findings, such as NAO-ozone in Europe and jet stream-ozone on North American, provided meaningful and substantial clues to our studies.

(3) In the revised version, the section 4&5 lengthened about 50**%, i.e., from 60 lines to 90 lines.** What's more important is the causality between May sea ice and OWI was verified by **a new numerical experiment by CAM5**. The proposed relationship and

physical mechanisms were **reproduced by the well-designed experiment** (Figure 12). The details can be found the attached revised texts.

(4) The goal of this study **was not prediction** of summer average MDA8 O_3. When we mentioned the predictions, we just emphasized the importance of our findings to seasonal O_3 prediction. Furthermore, our studies, based on long-term meteorological data, **could support scientific basis and improve the potential of prediction**. This is the further meaning of our finding. To avoid the confusing and the overstated problem, the words like "seasonal prediction" were modified or deleted.

(5) Throughout the manuscript, the writing was corrected to focus on the meteorological conditions related to O_3 production. In the Discussion, we also mentioned it as "**the OWI was still a substitution focusing on the impacts of the weather conditions**" and "Thus, the results in this study **concentrated on and emphasized the meteorological and climate factors**".

Revision:

(1) The revised manuscript without and with tracks were both uploaded for review.

(2) …For example, the prevailing positive phase of the North Atlantic Oscillation contributed to the increasing ozone concentration in western and northern Europe, through the anomalous atmospheric circulations to influence regional photochemical processes (Christoudias et al., 2012; Pausata et al., 2012)…

…The summer surface O_3 variability in North America is significantly modulated by the position of the jet stream (Lin et al., 2014). Barnes and Fiore (2013) pointed out jet position may dynamically modulate surface ozone variability in eastern North America and other northern mid-latitude regions…

…A strong positive correlation between the East Asian summer monsoon and summer mean ozone existed. The model simulation by Yang et al. (2014) illustrated that the changes in meteorological parameters, associated with East Asian summer monsoon, lead to 2–5% interannual variations of surface O_3 concentrations over central eastern China. Focusing on the dataset in 2014, a significantly strong west Pacific subtropical high resulted in higher relative humidity, more clouds, more rainfall, less ultraviolet radiation and lower air temperatures, which were unfavourable for the formation of O_3 (Zhao and Wang, 2017)…

(3) The revisions for section 4&5 can be found in the replies to Comment 1.2.

(4) The revisions for 4-(4) (5) can be found in the replies to Comment 1.1.

Specific/Minor Comments:

Line 10: Surface ozone pollution is only increasing in certain parts of the world. Please be specific about China here.

Reply:

The error has been corrected.

Revision:

Summer surface O_3 pollution has rapidly intensified **in China** recently, damaging human and ecosystem health.

Introduction: I find the discussion on “haze pollution” to be very confusing, especially because particulate pollution is not the focus in this paper. It would make the introduction much clearer to eliminate the use of “haze” and discuss only the O3 pollution issues in China.

Reply:

We mentioned the “haze pollution” to contrastively show that the haze is decreasing, however the ozone pollution is increasing and lack of research. The confusing writing was improved to **focus on the comparison and make it focus on the surface ozone pollution.**

Revision:

…Due to drastic air pollution control in China since 2013, **haze pollutions are being controlled in recent years** (The environmental statistics unit of stat-centre in Peking University, 2018), appearing as sharp decreasing in fine particulate matter ($PM_{2.5}$). **However, surface O_3 pollution**, which always occurred on clear and sunny days (Wang et al., 2017), **has not improved** (Li et al., 2018). The negative effects of surface O_3 pollution was not weaker than those of haze (Liu et al., 2018), but **the impacts of climate variability on surface O_3 pollution in China (Yang et al, 2014) have not been sufficiently studied.** In the major urban agglomerations in China…

Lines 26-27: Surface O3 is a major component of photochemical smog, so it is actually very frequently visible to humans when found in high amounts.

Reply:

According to the reviewer’s advice, the discussion about the visibility was **deleted**.

Revision:

Due to drastic air pollution control in China since 2013, haze pollutions are being controlled in recent years (The environmental statistics unit of stat-centre in Peking University, 2018), appearing as sharp decreasing in fine particulate matter ($PM_{2.5}$). However, surface O_3 pollution, which always occurred on clear and sunny days (Wang et al., 2017), has not improved (Li et al., 2018).

(O_3) pollution in summer (Ma et al., 2016; Tang et al., 2018). Due to drastic air pollution control in China since 2013,~~the low visibility it caused and its obvious unusual smell,~~ haze pollution~~ easily causes warning and~~ are being controlled in recent years (The environmental statistics unit of stat-~~center~~centre in Pe~~r~~king University, 2018), appearing as sharp decreasing in fine particulate matter ($PM_{2.5}$). However, surface O_3 pollution, which~~has~~ always occurred on clear and sunny days (Wang et al., 2017), ~~so it is not visible to humans.~~ has not improved (Li et al., 2018). The negative effects of surface O_3 pollution was not

Lines 27-28: I disagree with this sentence. Surface O3 pollution in China is now a heavily studied topic. Rewrite this sentence to mainly highlight the novel aspect of your research into this topic: "The impacts of climate variability on surface O3 pollution in China have not been sufficiently studied."

Reply:

The error was corrected, according to the reviewer's comment.

Revision:

…but **the impacts of climate variability on surface O_3 pollution in China** (Yang et al, 2014) have not been sufficiently studied…

Lines 28-29: This sentence on European pollution controls is out of place. Find a local example of pollution controls in China to discuss or remove this sentence entirely.

Reply:

The introduction of European clean air laws was confusing, and now was **deleted**. Thus, the introduction of the ozone polluted features f**ocused on those in China.**

Revision:

pollution in China~~, especially~~ (Yang et al, 2014) ~~ the impacts of climate variability,~~ have not been sufficiently studied.~~ Europe has benefitted from its rigorous air protection act and maintained good air quality, but the surface ozone levels still showed significant increases during 1995–2012 (Yan et al., 2017). In the major urban areas in China, the surface O_3 concentrations~~

Line 30: Please quote the current Chinese air quality standards for surface O3.

Reply:

The air quality standards was added in the manuscript.

Revision:

In the major urban agglomerations in China, such as Beijing-Tianjin-Hebei, Yangtze River delta and the Pearl River delta, the surface O_3 concentrations exceeded the ambient air quality standard **of China (i.e., 100 μg/m³)** by 100–200 % (Wang et al., 2017).

Lines 35-40: These examples of large-scale atmospheric circulation patterns affecting surface O3 are relevant, but need to be presented more clearly to allow the reader to understand why they are worth discussing.

Reply:

In the second paragraph of the introduction, the ideas how the climate anomalies (e.g., NAO, jet stream, west Pacific subtropical high and East Asia summer monsoon) were **expanded on**. The details can be found in the following revisions attached.

Revision:

…For example, the prevailing positive phase of the North Atlantic Oscillation contributed to the increasing ozone concentration in western and northern Europe, through the anomalous atmospheric circulations to influence regional photochemical processes (Christoudias et al., 2012; Pausata et al., 2012)…

…The summer surface O_3 variability in North America is significantly modulated by the position of the jet stream (Lin et al., 2014). Barnes and Fiore (2013) pointed out jet position may dynamically modulate surface ozone variability in eastern North America and other northern mid-latitude regions…

…A strong positive correlation between the East Asian summer monsoon and summer mean ozone existed. The model simulation by Yang et al. (2014) illustrated that the changes in meteorological parameters, associated with East Asian summer monsoon, lead to 2–5% interannual variations of surface O_3 concentrations over central eastern China. Focusing on the dataset in 2014, a significantly strong west Pacific subtropical high resulted in higher relative humidity, more clouds, more rainfall, less ultraviolet radiation and lower air temperatures, which were unfavourable for the formation of O_3 (Zhao and Wang, 2017)…

Lines 40-47: Similar comment as the one above. There are several studies discussed in one sentence each, but the organization makes this cumbersome to read. In general, the Introduction would benefit from a careful rewrite.

Lines 47-52: This paragraph is a good example of how the rest of the Introduction should be written to motivate carrying out this study.

Reply:

Lines 40-47 were also **expanded on**. The details can be found in the following revisions attached.

Revision:

…The photochemical reaction was the main local sources of O_3. The hot and dry environments and the violent solar radiation could accelerate the chemical conversion from the precursor to O_3 (An et al., 2009; Tong et al., 2017). In 2013, a severe heat wave, with highest temperature 41.1 ℃, contributed to the high O_3 concentration in the Yangtze River Delta (Pu et al., 2017). The frequency of large-scale, extreme heat events is closely related to atmospheric patterns, such as the Eurasia teleconnection pattern (EU; Pu et al., 2017; Li and Sun, 2018) and aerosol effective radiative forcing (Liu and Liao, 2017). The winds from a polluted area also transport O_3 and its precursors downwind (Doherty et al., 2013). Due to the close relationship between surface O_3 and meteorological conditions, the impacts of climate change on O_3 have been projected by various numerical models (Doherty et al., 2013; Melkonyan and Wagner, 2013; Zhu and Liao, 2016; Gaudel et al., 2018). Over eastern China, the surface ozone concentration and possibility of severe ozone pollution may both increase in the future (Wang et al., 2013)…

Line 79: The first figure introduced should not be supplemental figure. Figure S1 is discussed extensively in the text, so it would be useful to just make this Figure 1.

Figure S6: Much like Figure S1, this is a lot of text to dedicate to a figure that is buried in the Supplemental Information.

Reply:

The Figure S1, S6, S7, S8 and S11 were **moved to the main text** in the revised version. Now, there were 12 Figures in the main text and 6 Figures in the supplemental information.

Revision:

The mentioned Figures were Figure 1, 3, 5, 8 and 11 in the revised manuscript.

Figure S1 Caption: Green "triangle", not "triple"

Reply:

The error is corrected.

Revision:

The green **triangle** in panels b, d, f, and h illustrate the location of the SDZ station. The black box in panel h is the range of North China.

Line 98: Are these statistics only for June to August? Please be clear.

Reply:

It is for June to August.

Revision:

During the years 2007–2017, there were 126 NOP days and 155 MOP days **in summer** at SDZ station.

Line 101: Clarify that you are still referring to the O3 levels at SDZ.

Reply:

This sentence was clarified.

Throughout the manuscript, the MDA8 in SDZ station was denoted as **SDZ MDA8**, comparing to the **MDA8 in the other sites**.

Revision:

…although the meteorological conditions were **composited for the MOP and NOP days in SDZ** (Figure 2), the results were also appropriate for those in North China…

2017). The correlation coefficients between SDZ MDA8 and the observed MDA8 at the other sites were calculated and are shown in Figure 1 (b, d, f, h). The distribution of correlation coefficients is similar to the MDA8 on Figure 1 (a, c, e, g). The SDZ MDA8 significantly covaried with the MDA8 in North China in summer. Along with the increasing of the surface O_3 pollution, the covariation and the representativeness of SDZ MDA8 to the MDA8 in North China was strengthened. However,

Figure 1, panels g and h: Clarify in the figure caption which temperature is contoured and which is shaded in color. Does geopotential height at 500 or 250 hPa

tell you more about surface O3 variability than 200 hPa temperature?

Reply:

(1) The negligence was revived. **The SAT is with shading and the temperature at 200 hPa is contoured.**

(2) We also tried 500 hPa and the lower levels, which was positive and similar with the surface temperature. The temperature anomalies at 200 hPa was opposite with those below 300 hPa. 250 hPa was the transitional layer and the features was not as clear as 200 hPa. Therefore, **we chose the temperature difference between surface and 200 hPa.**

Revision:

Figure 2…(g–h) SAT (shading), and temperature at 200 hPa (contour)…

Lines 105-106: Are the northerly winds associated with higher surface O3 to the south of SDZ?

Reply:

(1) The ozone concentration in North China, most of where were located to the south of SDZ station. Due to the covariation (Figure 1), **the northerlies dispersed the O_3 precursors in North China, and the surface O_3 concentration was reduced**. As for the influenced area, it is depended on **the intensity of the northerlies**. In total, statistically, associated with the northerlies, the surface O_3 concentration reduced in North China. (2) We did not carefully examine the impacts of northerly wind on the ozone concentrations to the south of North China (i.e., far away from SDZ). Possibly, the influenced factors were different. According to the new publication by **Li et al (2018), the sensitive meteorological factors related to the ozone pollution in Yangtze River Delta was relative humidity, zonal and meridional wind, which was different with those in North China.**

Li, K., Jacob, D. J., Liao, H., Shen, L., Zhang, Q., Bates, K. H.: Anthropogenic drivers of 2013–2017 trends in summer surface ozone in China, P NATL ACAD SCI USA., https://doi.org/10.1073/pnas.1812168116, 2018

Line 108: Here and a couple of other locations, please fix the degree symbols.

Reply:

The similar errors were corrected throughout the manuscript.

Revision:

was reduced (Figure 2b). The correlation coefficient between the SDZ O_3 concentration and the area-averaged meridional wind at 10 m (35–50°N, 110–122.5°E, denoted as V10mI) was 0.39, exceeding the 99% confidence level. The cloudy skies and precipitation weakened the photochemical reaction by influencing exposure to ultraviolet rays. In addition, precipitation was also an important indicator of the wet removal efficiency (Figure 2f). In summer, a day without rain represents efficient solar radiation, in favor of the occurrence of surface O_3 pollution (Figure 2e). The correlation coefficient between the area-averaged precipitation (37.5–42.5°N, 112–127.5°E, denoted as PI) and the SDZ O_3 concentration was –0.35 (above the 99% confidence level), indicating that precipitation was connected with more NOP days.

In contrast, high SAT enhanced the photochemical reactions and resulted in higher surface O_3 concentrations (Figure 2 g). The correlation coefficient between the area-averaged difference in the temperature at the surface and 200 hPa (SAT minus temperature at 200 hPa, 37.5–47.5°N, 110–122.5°E, denoted as DTI) and the SDZ O_3 concentration was 0.49. Furthermore,

Lines 108-112: Please rewrite these sentences to more simply state that clouds and precipitation are unfavorable for surface O3 production, leading to the meteorological composite in Figure 1f.

Reply:

This sentence was revised.

Revision:

The cloudy skies and precipitation weakened the photochemical reaction by influencing exposure to ultraviolet rays. In addition, precipitation was also an important indicator of the wet removal efficiency (Figure 2f).

Line 116-117: The temperature of the upper troposphere is much more dynamicallythan radiatively-influenced at synoptic timescales (i.e. through tropopause height variations). This sentence should be removed.

Reply:

According to the reviewer's suggestion, the discussion about the reason, why cooler temperature in the high troposphere (T200) is favorable for surface ozone pollution, was **deleted**.

Because we cannot perfectly address it now, the question was leave as an open question in the "Conclusion and Discussion" section.

Revision:

…The processes how the weather conditions impacted the photochemical reaction were not deeply discussed here and have been analyzed in many previous studies by the atmospheric chemists. **However, the reason why the cooler high troposphere contributed to the surface ozone pollution was still an open question and needed further attention**…

Line 136: Were there any sites that had a larger correlation between MDA8 and OWI than the SDZ site?

Reply:

Although the correlation coefficients between the OWI and observed MDA8 at the other sites were significantly positive in North China (Figure 5), the CC, which were **was larger than that in SDZ station, were few (Figure R1).**

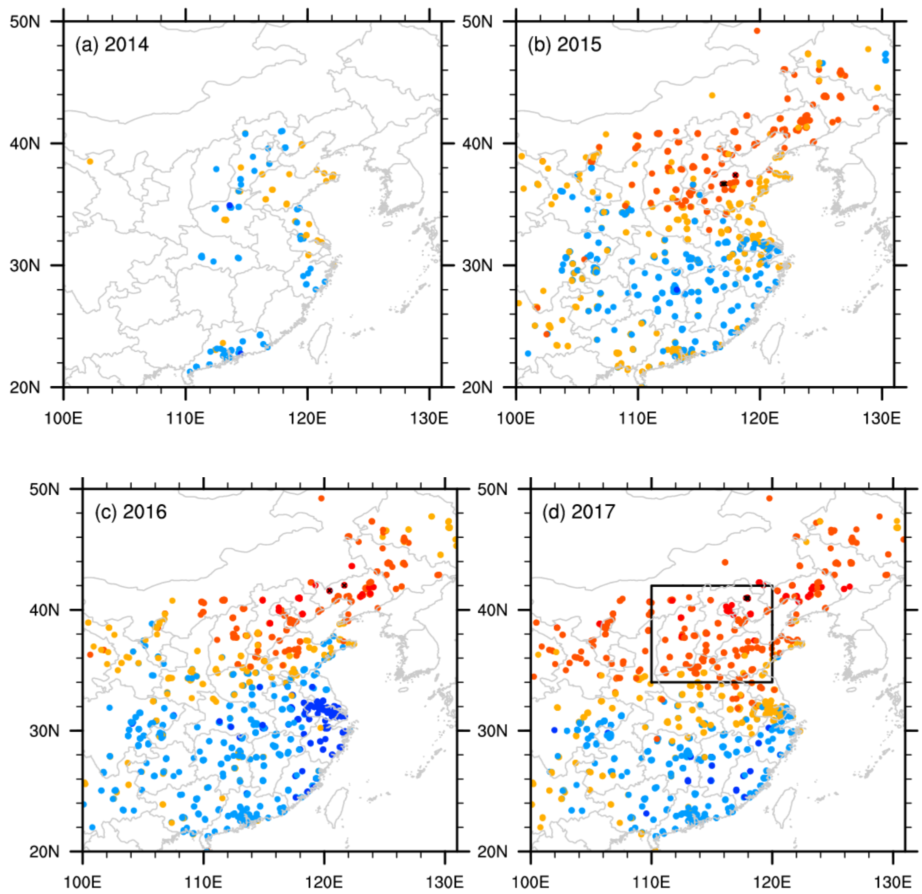


Figure R1. The correlation coefficients between the daily MDA8 and OWI from 2014 to 2017. **The black crosses indicate that the CC was larger than that in SDZ station**. The black box in panel d is the range of North China.

Lines 140-152 and Figure 3: I think analysis of OWI before 2006/2007 is not necessary, and introduces the uncertainty of a changing observing system (i.e. the satellite era beginning in 1979, ATOVS in 1998, etc.). These discussions are certainly outside of the scope of this paper, so I recommend not extending the OWI to periods when there are no O3 observations to support your analyses. Limit your discussion to 2007 to the present.

Reply:

(1) Most of the ozone observations were from 2014 to 2017 (Figure 1). Even at the SDZ station with measurements from 2006 to 2017, **the range of data was insufficient for the climate research**. Generally, the climate research required at least data for **30 years**.

(2) In this study, in addition to reveal the related meteorological conditions, we try to connect the ozone concentration with the climate anomalies. Thus, we calculated the daily OWI and then gained the **monthly mean OWI from 1979 to 2017**, which was treated as a substitution focusing on the impacts of the weather conditions.

(3) Once, we constructed the long-term OWI, discussion about the relationship with Arctic sea ice and large-scale atmospheric circulations became possible. This is the basis for the Section 4 & 5 in the manuscript, because **we cannot link the MDA8 with sea ice via short time series**.

(4) Although the goal of this study was not seasonal prediction, the findings potentially improve the possibility of seasonal prediction. Actually, the emissions linearly increased in recent year, **the annual incremental method could deduce the signal of emission and emphasized the climatic component and make the seasonal prediction feasible.**

The authors had successful experience in the seasonal predictions of haze pollution (Yin and Wang 2016, 2017).

Yin Z. C. , Wang H. J.， 2016, Seasonal Prediction of Winter Haze Days in the North-Central North China Plain，Atmos. Chem. Phys.，60（15）：1395~1400

Yin Z. C. , Wang H J. 2017. Statistical Prediction of Winter Haze Days in the North China Plain Using the Generalized Additive Model. Journal of Applied Meteorology and Climatology. 56:2411–2419

Figure 3: All of the other figures that show SDZ data begin in 2007. Why does this include 2006, and why is the line a different color green here? Why does the

NCEP/NCAR data end in 2014? Please clarify.

Reply:

(1) The data form 2017-2017 were the **training set**, while the data in 2006 was th**e test set**. “Although the range of the SDZ MDA8 was 2006–2017, only the data from 2007 to 2017 were used in the above OWI construction processes. Thus, the datasets in 2006 were **independent samples**, and could verify the performance of the OWI.”

(2) In the section 2, “The BLH of NCEP/NCAR dataset was only available from 1979 to 2014 in the website of the NOAA-CIRES 20th Century Reanalysis version 2c (Giese et al., 2016)”. **Due to the absence of BLH after 2014, thus, the OWI from NCEP/NCAR data was limited from 1979-2014.** It's important to note that the other variables used in this study was from 1979 to 2017.

Detailed explanation was added in the revised manuscript.

Revision:

…The monthly OWI was computed as the monthly mean of the daily OWI. During 2007–2017, the constructed JJA (June-July-August) mean OWI varied similarly with the observed MDA8 and captured the extremes (Figure 6). Although the range of the SDZ MDA8 was 2006–2017, only the data from 2007 to 2017 were used in the above OWI construction processes. Thus, the datasets in 2006 were independent samples, and could verify the performance of the OWI. The JJA mean OWI in 2006 successfully reflected the variation in observed MDA8; even the MDA8 in 2006 was the minimum, confirming the robustness of the OWI…

Figures 4 and 5: I thought the OWI was constructed by using some of these same meteorological variables. What is the value in calculating correlations between these variables and OWI?

Reply:

To answer this question, the **daily weather process** and **climate anomalies** must be distinguished. (1) The construction of the daily OWI was based on the **weather conditions**. (2) The daily OWI from 1979 to 2017 were calculated to obtain the climatic time series, i.e., the JJA mean OWI from 1979 to 2017. (3) The correlation coefficient between the JJA mean OWI and meteorological conditions were calculated from 1979 to 2017 to reveal the climatic connection.

Although there were similarity between the related weather conditions and the climatic anomalies, their meanings were substantially different.

(4) Based on the climatic connection, the contribution of May sea ice was studied, which cannot be supported by the weather analysis.

To enhance the theme, the title was also revised as "Arctic sea ice, Eurasia teleconnection pattern and summer surface ozone pollution in North China***: in terms of climate variability***".

Lines 170-177: This discussion is essentially a repeat of Lines 110-126. What is new here?

Reply:

The response can referred the above reply of comment related to **Figures 4 and 5.**

Although there were similarity between the related weather conditions and the climatic anomalies, their meanings were substantially different.

Lines 185-186: What sea ice variable is used here? Is this sea ice extent (generally referred to as ocean areas with at least 15% ice coverage)?

Reply:

The variable is the sea ice **area**.

Revision:

The averaged (green boxes in Figure 10a) **sea ice area** in May was calculated as the SI index, whose linear correlation coefficient with JJA OWI was 0.67 (after detrending) from 1979 to 2017.

Line 188: Was the MDA8 anomaly also detrended? Is the MDA8 anomaly an anomaly from the mean of all JJA 2007-2017 MDA8 values?

Reply:

The MDA8 anomalies was the original value **subtracted the mean** of all JJA 2007-2017 MDA8 values

Lines 205-207: As I understand your analysis, this statement is not correct (same with the abstract). The May sea ice extent contributes to about 60% of the interannual variability of OWI, not surface O3 pollution. There is a separate

relationship between OWI and MDA8 at SDZ to be considered. The May Arctic sea ice anomaly does not even have the same sign as the MDA8 anomaly about 30% of the time (Line 187).

Reply:

Another overstated expression, i.e., making OWI≈surface O3 pollution, was also corrected throughout the manuscript. In the Discussion, we also mentioned it as "**the OWI was still a substitution focusing on the impacts of the weather conditions**" and "Thus, the results in this study **concentrated on and emphasized the meteorological and climate factors**".

Revision:

The analysis focused on the O_3-related weather conditions, such as……

…Furthermore, due to the close connection between the preceding May Arctic sea ice and summer EU pattern, approximately 60% of the interannual variability of **O_3-related weather conditions** was attributed to Arctic sea ice to the north of Eurasia…

…This finding will aids in understanding the interannual variation of O_3 pollution, **specially the related meteorological conditions**…

"the linear and nonlinear relationships were both introduced using the generalized additive model (Figure 11), and the contribution of May sea ice to the interannual variability of **OWI** was approximately 60%."

…In order to extend the time range of this study, the OWI was constructed in North China. Although the feasibility of the construction approach was strictly examined, **the OWI was still a substitution focusing on the impacts of the weather conditions**. When discussing the impacts of atmospheric circulations, the linear trend was removed to weaken the signal of anthropogenic emissions. Thus, **the results in this study concentrated on and emphasized the meteorological and climate factors**. However, there is no doubt that the polluted emissions are the fundamental inducement of the surface O3 pollution…

Technical Corrections:

Line 15-16: Clarify by rewriting as "Increased solar radiation and high temperatures during the EUTP positive phase dramatically enhanced O3 production."

Reply:

According to the reviewer’s comment, the sentence was **rewritten**.

Revision:

Increased solar radiation and high temperature during the positive EU phase dramatically enhanced O_3 production.

Lines 24-25: See comments on the use of “haze” in my Specific Comments. This sentence should be removed or at least rewritten.

Reply:

We mentioned the “haze pollution” to contrastively show that the haze is decreasing, however the ozone pollution is increasing and lack of research. The confusing writing was **improved to focus on the comparison and make it focus on the surface ozone pollution.**

Revision:

…Due to drastic air pollution control in China since 2013, **haze pollutions are being controlled in recent years** (The environmental statistics unit of stat-centre in Peking University, 2018), appearing as sharp decreasing in fine particulate matter ($PM_{2.5}$). **However, surface O_3 pollution**, which always occurred on clear and sunny days (Wang et al., 2017), **has not improved** (Li et al., 2018). The negative effects of surface O_3 pollution was not weaker than those of haze (Liu et al., 2018), but **the impacts of climate variability on surface O_3 pollution in China (Yang et al, 2014) have not been sufficiently studied.** In the major urban agglomerations in China…

Line 25: Peking University?

Reply:

According to the reviewer’s comment, the error was corrected.

Revision:

Due to drastic air pollution control in China since 2013, haze pollutions are being controlled in recent years (The environmental statistics unit of stat-centre in **Peking** University, 2018), appearing as sharp decreasing in fine particulate matter ($PM_{2.5}$).

Line 32: Rewrite this sentence “Surface O3 is a secondary pollutant.”

Reply:

According to the reviewer’s comment, the sentence was **rewritten**.

Revision:

Surface O_3 is a secondary pollutant.

Line 33: Change “Sedimentation” to “Surface deposition” and “attenuation” to “dispersion”

Reply:

According to the reviewer’s comment, the sentence was rewritten.

Revision:

Surface deposition, dynamic transport and dispersion of O_3 are also closely related to atmospheric circulations.

Line 50: Change “were” to “was”

Reply:

According to the reviewer’s comment, the sentence was rewritten.

Revision:

The role of May Arctic sea ice, as a preceding and effective driver, **was** also analysed.

Line 64: Do you mean the NCEP/NCAR Reanalysis? Please refer to these products as the NCEP/NCAR Reanalysis, instead of NOAA.

Reply:

The expression of NOAA data has been changed to the **NCEP/NCAR data**.

Revision:

The daily mean and monthly mean ERA-Interim data were directly downloaded from the ERA-Interim websiteanalyzed in this study. Furthermore, the daily mean and monthly reanalysis datasets supported by the National Oceanic and Atmospheric Administration (NOAA) were also employed and denoted as NOAA NCEP/NCAR (National Center for Environmental Prediction and the National Center for Atmospheric Research) data. The 2.5°×2.5° geopotential height (Z), zonal and meridional wind, relative humidity, vertical velocity, air temperature at different pressure levels, SAT and wind, downward UV radiation, downward solar radiation, low and medium cloud cover were downloaded from the National Center for Environmental Prediction and the National Center for Atmospheric Research (Kalnay et al. 1996). The BLH of NCEP/NCAR dataset was only available from 1979 to 2014 in the NOAA data was derived fromthe website of the NOAA-CIRES 20th Century Reanalysis version 2c (Giese et al., 2016). The daily precipitation data was from the CPC global analysis of the daily precipitation dataset (Chen et al., 2008).

Line 82: “appeared to be delineated by the Yangtze River.”

Reply:

According to the reviewer’s comment, the sentence was **rewritten**.

Revision:

…O_3 concentrations in the high-mid latitudes were higher than those in the lower latitudes, which appeared to be **separated** by the Yangtze River…

Line 84: Delete “approximately yearly.”

Reply:

Deleted

Revision:

that time, the O_3 polluted region has expanded approximately yearly.

Line 86: Replace “almost higher than” with “nearly.” Also, what is the threshold of severe surface O3 pollution? Is this a definition set by the Chinese government? Are these O3 data publicly available?

Reply:

(1) According to the reviewer’s comment, the sentence was **rewritten**.

(2) The ozone data from 2014 to 2017 were **publicly available in the website** of the Ministry of Environmental Protection of China.

Revision:

higher than 120 μg/m^3. The observations, with maximum MDA8 higher than 265 μg/m^3 (i.e., the threshold of the server surface O3 pollution in China ~~Since~~) existed in the south of Hebei Province and the north of Shandong Province (Figure 1a). Since that time, the O_3 polluted region has expanded ~~approximately yearly~~. In 2017, the areas with summer mean MDA8 > 120 μg/m^3 were visibly enlarged. In North China, the summer mean MDA8 observations were larger than 150 μg/m^3, and the maximum MDA8 was ~~almost higher than~~ nearly 265 μg/m^3 ~~(i.e., the threshold of severe surface O_3 pollution)~~. South of the

Line 92: Rewrite this sentence, suggestion: "The distribution of correlation coefficients is similar to the MDA8 on Figure S1 panels a, c, e, and g."

Reply:

According to the reviewer's comment, the sentence was **rewritten**.

Revision:

The distribution of correlation coefficients is similar to the MDA8 on Figure 1 (a, c, e, g).

Line 93: There is an extra period after China.

Reply:

It is in **summer**.

Revision:

The SDZ MDA8 significantly covaried with the MDA8 in North China in summer.

Line 94: Change "diurnal" to "daily"

Reply:

The error was corrected.

Revision:

The **daily** difference in MDA8 was large, which contradicts the quasi-constant emission of ozone precursors.

Line 96 and in the references: Should be "Ministry of Environmental Protection"

Reply:

The error was corrected.

Revision:

(The Ministry of Environmental **Protection** of China, 2012)

Line 97: What is "nonsurface?" Please rename this to something like "non-polluted surface O3 levels".

Reply:

The "**nonsurface**" was renamed as non-surface O_3 polluted (NOP) level.

Revision:

The thresholds of non-surface O_3 polluted (NOP) level and moderate surface O_3 polluted (MOP) level are 100 μg/m³ and 215 μg/m³, respectively.

Line 114: Delete "sufficient"

Reply:

The "sufficient" was **deleted**.

Revision:

…indicating that precipitation was connected with more NOP days….

Lines 115-116: Rewrite: "In contrast, higher SAT enhances the photochemical reactions and resulted in higher surface O3 concentrations (Figure 1g)."

Reply:

According to the reviewer's comment, the sentence was **rewritten**.

Revision:

In contrast, high SAT enhanced the photochemical reactions and resulted in higher surface O_3 concentrations (Figure 2 g).

Line 121: Is this referring to the entrainment of O3 into the boundary layer? Please clarify and eliminate the word "downwash"

Reply:

According to the reviewer's comment, the sentence was **rewritten**.

Revision:

The entrainment of atmospheric ozone from the upper air into the boundary layer enlarged the surface O_3 concentration

Line 126: Use NCEP/NCAR reanalysis.

Reply:

According to the reviewer's comment, the sentence was **corrected**.

Revision:

…the above composite analysis was repeated with NCEP/NCAR reanalysis data, and identical results were obtained…

Line 132: Delete "In contrast"

Reply:

The "**In contrast**" was **deleted**.

Revision:

measured MDA8 during 2007–2017 (i.e., 92 days × 11 years). ~~In contrast, t~~The correlation coefficient between the observed MDA8 and daily OWI was also 0.61 for the 11 year period. Thus, the OWI was easily constructed by accumulating the

Figure S5: Either add a second panel with the ERA-Interim data for comparison or remove this figure. Consider also my comments about the inclusion of NCEP/NCAR Reanalysis in this paper in general.

Reply:

Add a second panel with the ERA-Interim data for comparison.

Revision:

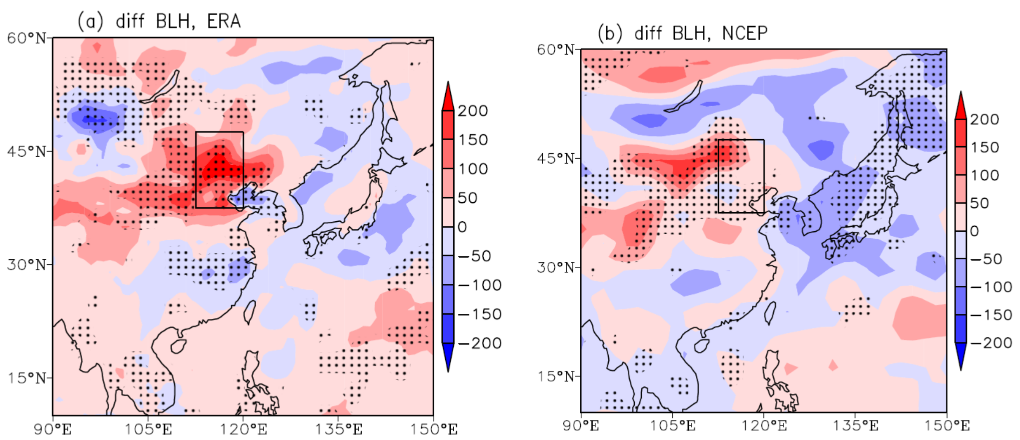


Figure S3. Differences in the boundary layer height between the MOP and NOP events during 2007–2014, basing on the ERA-Interim (a) and NCEP/NCAR datasets (b). The black dots denote that the composite passed the 95% confidence level. The boxes represent the area to calculate the daily OWI. These composites were calculated using the NOAA datasets.

Line 141: NCEP/NCAR reanalysis.

Reply:

According to the reviewer's comment, the sentence was **corrected**.

Revision:

Here, the daily OWI was calculated with both ERA-Interim and NCEP/NCAR reanalysis data from 1979.

Figure S11 Caption: "1979 to 2017", correct?

Reply:

Yes, it is 1979 to **2017**.

Revision:

Figure 11. The variation in the observational OWI (black) and the fitted OWI by the generalized additive model (red) from 1979 to 2017