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Response to Referee #2

This study conducted observational and modeling analysis of baseline ozone in oceanic air at Sheshan Island (SSI), which is located to the east of Shanghai city. The authors reported a six-year measurement of ozone concentration at SSI and its ozone level is much high than the value of downtown site in Shanghai. They further highlight the importance of understanding the interaction between urban plume and oceanic inflows in ozone pollution. In particular, their modeling results show that ozone in the oceanic inflows can enhance urban ozone by 20-30%.

We thank the reviewer for all the insightful comments. Please see our point-by-point response (in blue) to the general and specific comments below. The changes that have been made to the manuscript are also listed.

Overall, this manuscript is well structured and sites in the scope of this journal. Recent studies have increasingly focused on urban ozone pollution in China, but study on background ozone is still very limited. As such, this study could enrich our understanding of ozone pollution in China, particularly for coastal cities. Although this manuscript is publishable, the current version should be improved in terms of presentation and clarification. I would like the authors to address my following comments.

-This study shows observed ozone levels in a remote site and urban site. In fact, urban ozone in Shanghai are available from Chinese measurement network. It will be great if the authors could have more ozone measurements in this study. For example, Figure 8 is a good place to show more urban ozone data.

Response: Thanks for the suggestions. Since O_3 measurements in urban Shanghai from Chinese measurement network are only publicly available after March 2013, the data length cannot cover the whole study period in this study. To provide more measurements in Fig. 8, we added continuous O_3 measurements obtained from Sheshan (SS), Pudong (PD), and DT (Dongtan) sites in Shanghai. O_3 concentrations were measured using the same method as those at SSI and XJH during the period 2012–2017. Figure 8 and Table 4 have been revised same as Fig. R1 and Table R1. Corresponding discussions in Sect. 3.5 are revised as follows:

"Figure 8 displays the simulated and observed monthly mean distributions of surface O_3 concentrations in BC_40, BC_50 and BC_60 scenarios, respectively. In addition to the observations at XJH and SSI, O_3 measurements obtained from other three sites, Pudong (PD, suburban), Sheshan (SS, rural), and Dongtan (DT, rural), during the same period were introduced to evaluate the model's performance in simulating O_3 in Shanghai. The O_3 concentrations at all the sites were measured using the same method as described in Sect. 2.1. The calculated distributions of O_3 agree with observations, which exhibit lower values in urban regions compared to those in rural and ocean areas, indicating strong O_3 depressions in the city of Shanghai due to the VOC-limited O_3 formation regime. The R values between the simulated and observed O_3 concentrations are all larger than 0.50 at continental sites (XJH, PD, SS, and DT), suggesting good prediction of O_3 variations by the model.

Table 4 displays the statistical results of the comparisons between the simulated and observed surface O_3 concentrations at different sites in Shanghai. Generally, the WRF-Chem model underestimates O_3 concentrations at all the sites in most cases. Taken the BC_40 scenario for example, the O_3 concentrations are underestimated by 9.4–27.6% at continental sites and 36.1% at SSI, suggesting larger underestimation of O_3 concentrations in oceanic regions. Model results further suggest that elevated O_3 levels in the eastern chemical BCs would lead to increases in O_3 concentrations at both urban and remote sites when the prevailing winds are mostly easterly in Shanghai. With O_3 concentrations increasing from 40 to 60 ppbv in the easterly oceanic air inflows, the simulated monthly mean O_3 concentrations increase by 7.0–9.7 ppbv at continental sites and 10.4 ppbv at SSI. The underestimation of O_3 levels by the model is also greatly improved in the BC_60 scenario, when the chemical BCs of O_3 are more close to the observations. Compared to those in the BC_40 scenario, the normalized mean bias (NMBs) of the predicted O_3 concentrations reduced at most sites in the BC_60 scenario, for example from -36.1 % to -18.1 % at SSI and -27.6% to -4.6% at XJH, suggesting a crucial role of the eastern oceanic air inflows in influencing O_3 air quality in Shanghai."

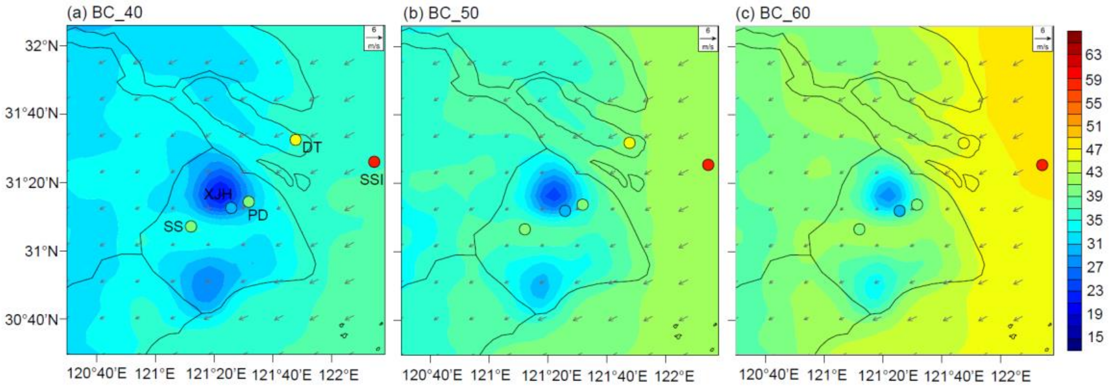

Figure R1 Calculated distributions of monthly mean O_3 concentrations (shades, ppbv) from BC_40, BC_50 and BC_60 simulations, respectively in September 2014. Model results are compared with observed mean O_3 concentrations (circles, ppbv) obtained from Sheshan (SS), Xujiahua (XJH), Pudong (PD), DT (Dongtan) and Sheshan Island (SSI) sites. Also shown is the calculated wind field (m s^{-1}) averaged over the same period.

Table R1 Statistical results of the comparisons between the simulated and observed surface O_3 concentrations at Sheshan (SS), Xujiahua (XJH), Pudong (PD), DT (Dongtan) and Sheshan Island (SSI) sites during September 2014. The calculated O_3 levels are obtained from BC_40, BC_50 and BC_60 simulations, respectively. Values of the average surface O_3 concentrations (Mean) and normalized mean bias (NMB) are displayed. The NMB is defined as NMB=$\frac{\sum_{i=1}^{n}(P_i-O_i)}{\sum_{i=1}^{n}O_i}$, where P_i and O_i are predicted and observed ozone mixing ratios for sample *i*, *n* is the number of total samples (numbers in parentheses).

	Cases	SS (681)	XJH (641)	PD (690)	DT (690)	SSI (720)
Mean (ppbv)	Observation	39.7	30.4	40.3	46.4	57.7
	BC_40	36.0	22.0	29.5	35.3	36.9
	BC_50	39.1	25.1	33.3	39.6	41.8
	BC_60	43.1	29.0	37.9	45.0	47.3
NMB(%)	BC_40	-9.4	-27.6	-26.7	-23.9	-36.1
	BC_50	-1.5	-17.5	-17.2	-14.5	-27.5

BC_60	8.6	-4.6	-5.9	-3.0	-18.1

- This study gives daily mean of ozone in both observational and modeling calculation. I am wondering if the authors can show more results for MDA8 ozone. Since MDA8 ozone is the standard air quality metric for ozone.

Response: Thanks for the suggestions. We have presented results for MDA8 O_3 in the revised manuscript. The new results added are as follows:

Sect. 3.2:" The observed mean daily maximum 8-h average (MAD8) O_3 concentrations exhibited same differences between the two sites, which were 40.1 and 62.0 ppbv, respectively at XJH and SSI."

Sect. 3.3:" The monthly mean MDA8 and daily extreme values of O_3 exhibited similar differences between the two sites. The calculated increasing rates of MDA8 O_3, $O_{3\text{-max}}$ and $O_{3\text{-min}}$ were 2.73, 2.77, and 1.35 ppbv yr^{-1} ($\alpha<0.05$), respectively at XJH, and 1.01, 1.35, and 1.27 ppbv yr^{-1} ($\alpha>0.10$), respectively at SSI."

-Line 27: "production" might be more appropriate than "oxidation".

Response: Revised.

-Line 89: please spell out months.

Response: Revised.

-Lines 252-253: will this ratio be helpful in this study?

Response: The ratio of daily maximum O_3 concentration ($O_{3\text{-max}}$) to minimum O_3 concentration ($O_{3\text{-min}}$) was usually regarded as an indicator to identify if a site could be considered as a typical background site as suggested in previous studies (Cvitas and Klasinc 1993; Cvitas et al., 1995; Vingarzan, 2004). For SSI, the mean ratio of $O_{3\text{-max}}$/ $O_{3\text{-min}}$ was calculated to be 3.03 during the study period, which was consistent with the typical values observed at continental background sites in China (Xu et al., 2008; Meng et al., 2009; Gu et al., 2020). In September and October, the ratio exhibited even low values at SSI, ranging from 1.61–2.35. The results helped to further indicate that the observed O_3 at SSI, especially in September and October, were least contaminated by regional pollution. And the SSI site could be regarded as a typical oceanic background site, providing a good proxy to study the baseline oxidation capacity of oceanic atmosphere in eastern China.

-Line 293: “few” looks not reasonable, since you still saw an increase trend of 1.12ppb yr^{-1}.

Response: Thanks for pointing out that. This part has been revised as :”… the statistically insignificant changes of O_3 detected at SSI indicated that O_3 in the oceanic air remained a constant level during the study period and was less influenced by the decreases of NO_x emissions.”

-Lines 346-348: is there any changes in ozone production sensitivity in response to NOx control?

Response: Yes. Based on measurements obtained from the same sites, Xu et al. (2019) has carefully examined the response of O_3 production sensitivity to NO_x reductions in Shanghai during the past decade. The O_3 isopleth diagram (Fig. R2) constructed by the Ozone Isopleth Plotting Package Research (OZIPR) model suggested that the O_3 production had moved from strong VOC-limited regime to slight VOC-limited regime in both urban and suburban sites in Shanghai due to the significant NO_x reductions and slight VOCs changes from 2009 to 2015. In 2017, the observed mean NO_x concentrations at XJH and PD decreased by 3.5 and 0.3 ppbv, respectively compared to those (33.2 ppbv at XJH and 22.6 ppbv at PD) in 2015, indicating that the O_3 production could still be VOC-limited in Shanghai according to Fig. S1. The results suggested that the O_3 production remained VOC-limited in Shanghai during the study period and the changes in O_3 production induced by NO_x reductions did not affect the main conclusion of the manuscript.

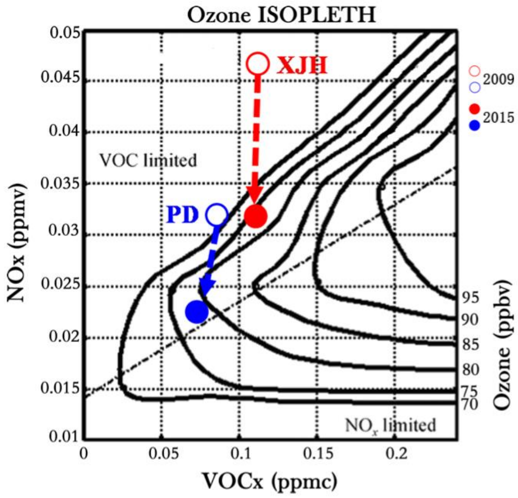

Figure R2 The O_3 isopleth diagram constructed by the OZIPR model in Shanghai (Xu et al., 2019).

We have revised this part as:" The results are in accordance with Tie et al. (2013) and Xu et al. (2019), who suggested that Shanghai and a broader regional area surrounding the city were all in the VOC-limited O_3 formation regime during the study period."

-Line 397: remove space before "%".

Response: Removed.

-Line 492: α should be <0.05 according to Table 3.

Response: Revised.

Reference

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