We are very grateful to the reviewers for their valuable comments and suggestions, which have helped us greatly in improving our manuscript. We have addressed all the comments and revised the manuscript accordingly. The point-to-point responses are provided below in Italic.

Anonymous Referee #1

General Comment

This paper examined the tropospheric ozone in East Asia in terms of the influence of various source regions, particularly focused on the regions outside East Asia, they called them as "foreign ozone". The topic of the paper is well within the scope of the journal. The model used and the methods to deduce the influence of each different source region are adequate and have been applied so far in various studies for similar purpose. The results shown in the paper are generally consistent with the facts published in the previous literatures. This gives a certain reliability to the analysis done in this paper, but at the same time, the novelty of this paper over those previous studies is not clearly shown in the manuscript. For example, the authors reviewed the roles of East Asian Monsoon on the foreign ozone in East Asia in "Introduction", but the findings of this paper written in "Abstract" is quite similar to what was reviewed there. The author argued that this paper provided a comprehensive assessment of the influence of foreign ozone on the East Asian tropospheric ozone, but if they just want a comprehensive assessment, writing a review paper is more suitable, and actually the review given in this paper is quite comprehensive. I suggest the authors should state more clearly what they achieved on top of the previous studies to be published in the journal.

This is my general concern.

Thanks for the reviewer's comments and suggestions. We added more statements in this revision in various sections on what is new in our study, mostly in the section of Discussion and Conclusions. This study reveals the significant foreign influences on

tropospheric ozone over East Asia through global atmospheric transport and gains some new insights. Firstly, this study comprehensively assessed foreign influences on tropospheric ozone over East Asia, while previous studies investigated ozone transport from one or a few foreign regions (X. Li et al., 2014; Chakraborty et al., 2015), that during one or a few seasons (Ni et al., 2018) or only surface ozone in East Asia (Wang et al., 2011). Comparisons with previous studies show that, despite some disagreements concerning various details, our results appear to be reasonable.

Secondly, we examined the foreign influence on ozone in East Asia throughout all tropospheric columns. The simulations show that the concentration of foreign ozone increases remarkably with altitude and is much higher than its native counterpart in the middle and upper troposphere. The influence in the East Asian middle and upper troposphere is important to climate change because of the considerable ozone radiative forcing over the area (Myhre et al., 2017). Such an impact has been rarely documented (Sudo and Akimoto, 2007).

Thirdly, we highlight the influences of EAM on the seasonal and interannual variations of foreign ozone distribution in East Asia, primarily through the vertical transport. Advancing from Zhu et al. (2017) for North American ozone, significant correlations between the strength of EAM and the ozone transport from various foreign regions including Europe, South Asia, and Southeast Asia have been found. These findings provide further understanding of the mechanisms of the intercontinental transport of air pollutants to East Asia.

Major Comment:

Almost all analysis was done for the average over East Asia. As previous studies have shown that the relative contributions of various source regions can vary considerably depending on the location within East Asia. So, I cannot fully understand the meaning

of such “East Asian averaged” contributions of various source regions. Actually, the latitudinal dependence in each foreign and native contributions were analyzed, but I guess the longitudinal dependence should be also large enough to be analyzed.

Thanks for the points. We have added two figures (Figures 3 and 8) to show how foreign ozone distributes horizontally over East Asia. The longitudinal variations of foreign ozone have been analysed as well (Figure S6).

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Figure 3 compares the fractional contributions of native and foreign sources for ozone over East Asia in terms of the annual mean. The fractional contribution of foreign ozone at high altitudes is greater than that at the surface, and can reach a regional mean of up to 68% at 500 hPa (Figure 3f). At the surface, the fractional contribution of foreign ozone is lowest over South China, where it is lower than that of native ozone (Figure 3d and 3h). The analysis has been added in the second paragraph of section 3.1.

Figure 8 presents how foreign ozone from different source regions distributes horizontally in the middle troposphere, illustrating significant foreign impacts on ozone over East Asia at the altitudes. The streamlines in Figure 8 roughly show the transport pathways, demonstrating the importance of the westerlies in driving the ozone transport from North America, Europe, Africa, and central Asia to East Asia. The analysis has been added in the first paragraph of section 3.2.1.

The longitudinal variations of foreign ozone from different source regions over East Asia are shown in Figure S6. In the East Asian middle and upper troposphere, they are less obvious than the latitudinal variations, especially in winter (Figure 10 vs. Figure S6). In the East Asian middle troposphere (500 hPa), central Asian and South Asian ozone decreases with longitude in summer, varying insignificantly with longitude in winter. At the East Asian surface, ozone from the two regions decreases

with longitude. Longitudinal variations of ozone from North America, Europe, Africa, and Southeast Asia are less obvious than that for central Asia and South Asia. The analysis has been added in the last paragraph of section 3.2.3.

Specific Comments:

- L45: The terms “native” and “foreign” are used before their definition is given in Table 2.

Thanks. Table 2 is moved into the supplement as Table S1. ‘Foreign ozone’ and ‘native ozone’ have been explained when the terms first appear.

- L83-85: Is the "transport" itself associated with thing other than meteorology such as emission and/or chemistry?

The ‘transport’ process itself is driven by the meteorology, specifically the atmospheric circulation or the wind field. The amount of ozone brought by the transport from the source region to the receptor region is related to the emissions and chemistry. Therefore, the influences of the transport on ozone over the receptor region is associated with all these factors. This sentence has been revised.

-L124-125: How did you treat CH4 chemistry in the model? Is it fully represented?

In the full chemistry simulation, the CH_4 concentrations were fixed throughout the troposphere to annual zonal mean values in four latitudinal bands (90N-30N, 30N-Eq., Eq.-30S, and 30S-90S). The global annual mean anthropogenic emissions of CH_4 were from EDGAR v4.2. In our sensitivity simulations, the effects of CH_4 emissions on anthropogenic ozone were excluded. This limitation has been added in the discussion section.

- L132-136: I don’t think these detailed definition of regions are necessary, since Figure 1 shows them visually and they can be found in its caption.

Agree. The definition of regions is removed.

- L146 (formula (1)): How is the consistency between CTRL-EAnth-GLO and the sum in the denominator of the first term? How are they close to each other? Should be explained somewhere in the text.

In Equation (1), $\sum_{i=1}^{8}$ (CTRL - EAnth-X_i) is the sum of the ozone response to the 100% perturbation for each region, CTRL - EAnth-GLO is the ozone response to the 100% perturbation for the globe. In the East Asian troposphere, ozone concentration from $\sum_{i=1}^{8}$ (CTRL - EAnth-X_i) is 0-4 ppbv (0-20%) higher than that from CTRL - EAnth-GLO (Figure S1). Figure S1 and explanations are added in this revision.

- L159-160: The production and loss of ozone can vary considerably with in a day, so I imagine using daily production and loss data should have bad consequences on the simulated tagged ozone concentration. Did you check the validity for using the daily values for them?

Thanks for this point. Due to the diurnal variations of ozone and the nonlinearity in chemistry, using daily production and loss data is one of the uncertainties for the tagged ozone simulation. We have compared the simulations between the full chemistry run and the tagged ozone run to assess the overall uncertainty of tagged ozone simulation (Figures S2-S3). The results show that the difference of the ozone concentrations in the two simulations is within ±5%. Results from the two types of simulations were also compared in Han et al. (2018). We also listed this as one of the sources of uncertainties in the section of Discussion and Conclusions.

- Table 2: I don't think Table 2 could effectively explain the different definition of the terminology used in the manuscript. For me, the caption of Table 2 is easier to understand what you want to explain than Table2 itself and the descriptions in the

main text (L194-210).

Table 2 has been moved into the supplement (Table S1). The terms are explained at their first appearance or along with the experiment description.

- L233-234: You can not compare the contribution of foreign ozone on whole East Asia and that on China

Thanks for this point. The sentence is removed.

- L248: How did you calculate the chemical lifetime? Explain it in the text.

'The chemical lifetime' has been revised to 'the lifetime'. For each model grid in the boundary layer, the lifetime of ozone was calculated by the daily average dry deposition and chemical loss rate of ozone. For each grid in the free troposphere, only the chemical loss rate of ozone is used. The explanation is added in the revision.

- L251-252: Only the dry deposition could be the cause of the difference? Are there any other causes which should be mentioned here?

The dry deposition and active chemical reactions of ozone in the boundary layer are the two main reasons for the shorter lifetime of ozone at the surface than in the free troposphere. The sentence has been revised accordingly.

- L267-269: This part should be more specific. Where is the East Asian trough? Which region of downdraft you are referring?

The East Asian trough in the middle troposphere is an important feature of the EAWM system. It locates along ~130-140^{o}E in winter (see Figure 6a in Y. Zhu et al. (2017)). Downdrafts prevail behind the East Asian trough in winter from 100^{o}E to 140^{o}E. The locations of the East Asian trough and downdrafts are added in the text.

- L284-287: This sentence is quite hard to understand logically. The difference

between foreign and foreign anthropogenic O3 is not mentioned in the previous sentences. I cannot understand what you want to mean here.

Thanks. The sentence is removed.

- L342: Why the contribution from Africa in winter can be so large? Why it can be larger than that from SAS SEAS where much closer to EAS.

Thanks for this question. Ozone transport from Africa to the East Asian middle and upper troposphere is mainly driven by the Hadley circulation and the subtropical westerlies. Unlike South Asia and Southeast Asia, Africa covers areas in the Northern Hemisphere (NH) and the Southern Hemisphere, with around three-quarters of the continent in the tropics. In NH winter, there still exists strong convection over the intertropical convergence zone (ITCZ) in Africa. In NH winter, the ITCZ in Africa uplifts biogenic emissions to the middle and upper troposphere, where is with high lightning NO_x emissions. Therefore, ozone concentrations in the African middle and upper troposphere are relatively high. Furthermore, African ozone in the middle and upper troposphere can be efficiently transported to East Asia by the subtropical westerlies. Compared with Africa, although South Asian and Southeast Asia are more close to East Asia, the atmospheric circulations are less favorable to the ozone transport to East Asia (Figure S5). See Han et al. (2018) for more specific analysis of ozone transport from Africa to East Asia. We added explanations on this in the third paragraph of section 3.2.1 in this revision.

- L442 (formula(8)): What is U'850?

Thanks. U'850 is the anomaly of the zonal wind at 850 hPa. The explanation is added.

- L484-487: Where should I look at in Figure 3 and 7 to find these values? Is it annual evaluation or seasonal? This is a quite blur sentence.

This sentence has been revised. The concentrations of foreign ozone and native ozone

is compared on the annual average in this sentence. Such a comparison in the four seasons is added in section 3.1.