We thank the reviewers for their constructive comments, suggestions, and corrections. In our revision, we have addressed the reviewer's concerns. The following is a one-to- one response to their questions.

Response to Comments by Anonymous Referee #1

General Comments:

The authors provide a detailed analysis for the long-range transport of tropospheric O_3 from Africa to Asia. They indicated that African O_3 have important influences on free tropospheric O_3 over Asia, and the imported African O_3 peaks in winter because of the shifts of transport and emission patterns. I recommend the paper for publication after consideration of the points below.

1) The paper isn't concise enough for me. For example, Section 5 provides a summary for the transport and emission processes, which is actually a repeat of Section 4.2. In addition, considering the small contribution from SHAF (shown by Figure 4), it may not be necessary to have an individual section (Section 4.3) to discuss its influence.

Thanks for the comments and suggestions. We have constructed the paper to make it more concise. The presentation is polished throughout the paper. Section 5 in the last version has been removed and section 4.2 in the last version (now section 3.2) has been polished. We have recognized the section on the interhemispheric transport of ozone from SNAF and added more analyses in this section. Therefore, we think it is better to keep this section.

2) The discussion should be improved. The authors should explain why the seasonal variability of biogenic isoprene is so weak (Figure 6); and revise the discussion about the contributions from various sources (i.e. biogenic, biomass burning and lightning, Section 4.2).

Thanks for the points. In the last version, the color scale for the seasonal variation of biogenic isoprene used in Figure 6 was not appropriate so that the seasonal variation was not shown apparently. We have edited the color scale so to better show the magnitude of the seasonal variation of biogenic isoprene (now Figure 7). The seasonal variation of biogenic isoprene is also shown in Figure 8 for the regional *means. The discussion about the contributions from various sources has been revised in section 3.3.*

Specific Comments:

1: Line 147-149 Are the O_3 production and loss rates generated using the full-chemistry simulation with the current model settings or from other studies (Wang et al. 1998; Zhang et al. 2008)?

In this study, we generated the ozone production and loss rates from the full-chemistry simulation using the current model settings of GEOS-Chem v9-02. We have clarified this in this revision.

2: Line 149-153 It would be better to show these regions as boxes in the map (e.g. Figure 5). It is difficult to imagine the regions just based on these lat/lon numbers.

Thanks for your suggestion. We have added Fig. 1 to show the definition of the regions. The sites used in the GEOS-Chem validation and trajectory analysis are also shown in Fig. 1.

3: Line 155-157 Did the authors evaluate the possible influences from interannual variations of meteorology on chemistry?

Previous studies have shown that the interannual variation of meteorology has impact on the production and loss of ozone (using ENSO as an example: Sekiya and Sudo, 2012, 2014; Hou et al., 2016). Using 39-year simulations from the global chemical transport CHASER of two experiments by fixing the emissions of ozone precursors and ozone production/loss rate, Sekiya and Sudo (2012) shows that the influence from the interannual variations of meteorology on the impact of transport on tropospheric column ozone is greater than that of chemistry over most of the globe. Sekiya and Sudo (2014) further suggested that the impact of chemistry is comparable to the impact of transport in the tropics. Hou et al. (2016) shows that El Nino and La Nina show opposite effect on ozone production in the tropical Pacific.

In this study, we focus on the impact of the interannual variation of meteorology on *the transport of African ozone to Asia. Therefore, we keep the ozone production and loss rate fixed in one year and allow the meteorology to vary from year to year. To test our results, we have generated ozone production rate and lose frequency in other two separate years. Using these two sets of daily ozone production and loss frequency, two additional time series of 20-year simulations can be generated. The three time series show consistent interannual variation in transport of African ozone to the Asian troposphere, which is driven only by meteorology. The differences in the daily ozone production rate and lose frequency among the three data sets reflect partially the meteorological influence on ozone chemistry. This sensitivity test suggests that although meteorology also impacts ozone chemistry, our results on the interannual variation of African ozone transport that is simulated with fixed chemistry in a year appear robust.*

Reference: Hou, X., B. Zhu, D. Fei, X. Zhu, H. Kang, and D. Wang (2016), Simulation of tropical tropospheric ozone variation from 1982 to 2010: The meteorological impact of two types of ENSO event, J. Geophys. Res. Atmos., 121, 9220–9236, doi:10.1002/2016JD024945.

4: Line 166-167 Is there any other station available? Why are these three stations selected?

GEOS-Chem simulations have been validated with ozonesonde data extensively, for example, in North America (Zhang et al., 2008; Zhu et al., 2017b), Europe (Kim et al., 2015), and East Asia (Wang et al., 2011; Zhu et al., 2017a; Zhu et al., 2017b). However, few studies have validated the simulations in Africa. We specifically validate the performance of GEOS-Chem over Africa for an enhanced confidence on our analysis. These three stations are selected for their representative locations and relative long records in Africa. In this version, the ozone data from three ozonesonde stations in India are added for the GEOS-Chem validation. In addition, the Tropospheric Emission Spectrometer (TES) satellite observations are compared with the GEOS-Chem simulation in the middle troposphere (see the supplement file).

5: Section 2.3 Is the meteorological data the same as used by the HYSPLIT model? If they are the same, it would be better to combine Section 2.2 with Section 2.3.

The meteorological data are the same as used by the HYSPLIT model. The two parts have been combined into Section 2.3.

6: Line 237-239 The influence of African O_3 to south America across Atlantic is discussed, but isn't shown in the Figure. It could be better to remove the discussion about the transatlantic transport here.

The discussion about the transatlantic transport here has been removed.

7: Line 262-269 Although may not be necessary to explain, I am just curious about the reason for the discrepancy between western and eastern Africa.

In general, the latitudinal position of ITCZ follows the sun. In eastern Africa, the seasonal migration of ITCZ with latitude is more symmetrical around the equator, while in western Africa, the migration is limited (Collier and Hughes, 2011). The seasonal migration of the ITCZ in western Africa is complicated. Generally, in NH summer, the convergence zone is formed by the flows from the Atlantic cold tongue and the Saharan heat low, locating around 20^{o}N (Nicholson, 2009, 2013). In NH winter, the anticyclonic wind from northern Africa converges with the southerly wind from Atlantic. The ITCZ over western Africa still stays in the continent (Nicholson, 2013). Therefore, the seasonal migration of the ITCZ in western Africa is within a narrower range of latitudes than in eastern Africa.

Reference: Sharon E. Nicholson, "The West African Sahel: A Review of Recent Studies on the Rainfall Regime and Its Interannual Variability," ISRN Meteorology, vol. 2013, Article ID 453521, 32 pages, 2013. doi:10.1155/2013/453521

8: Line 276-277 Figure 6 shows significant seasonal variation for biomass burning CO. Surprisingly, the seasonal variation of biogenic isoprene is ignorable, which seems inconsistent with other study (e.g. Marais et al. 2014). Is it associated with the color scale? On the other hand, the normalized magnitudes of seasonal variability

(Figure 7) are comparable between CO and isoprene. Is it due to the usage of standard deviation in the calculation? The approach for normalization is confusing.

Marais, E. A., Jacob, D. J., Guenther, A., Chance, K., Kurosu, T. P., Murphy, J. G., Reeves, C. E., and Pye, H. O. T.: Improved model of isoprene emissions in Africa using Ozone Monitoring Instrument (OMI) satellite observations of formaldehyde: implications for oxidants and particulate matter, Atmos. Chem. Phys., 14, 7693-7703, https://doi.org/10.5194/acp-14-7693-2014, 2014.

Thanks for the points. Yes, the small seasonal variation in the old Figure 6 for the seasonal variation of biogenic isoprene is indeed due to the use of the color scale. We have edited the color scale in Fig. 7so that the seasonal variation of biogenic isoprene in Africa is better presented. The biogenic emission peaks in spring and autumn. The magnitude of biogenic isoprene is comparable to the results in Marais et al. (2014). Fig. 8 shows the seasonal variability of isoprene and CO. The units are the same as them in Fig. 7. Normalization is not taken any more in this revision to avoid confusing.

9: Line 315-362 The discussion in this section is superficial. The authors discuss the contributions from various sources without detailed calculations. For example, the authors indicated: 1) "In boreal spring, a region with high ozone concentrations (>40 ppbv) appears in higher altitudes and … mainly due to the highest biogenic emissions in the NHAF" 2) "In boreal autumn, the locations of the ITCZ and the Hadley cell are similar to these in boreal spring. Ozone in the African middle troposphere ... attributed to stronger lightning NOx emission" However, there is no evidence to demonstrate that the contributions from biogenic and lightning activities are evaluated carefully. The discussion is simply based on the spatial distribution of Figure 6. The biogenic and lightning activities are highly similar between spring and fall, and it is hard to explain why the spring-time O_3 is biogenic dominant, whereas autumn-time O_3 is lightning dominant.

Thanks for the comments. Aghedo et al. (2007) has shown that the biogenic and lightning emissions are the two important sources influencing African middle and *upper tropospheric ozone and affecting global tropospheric ozone burden. To further explore the differences between the situations in NH spring and in NH autumn, we do 3 sensitivity experiments by switching off the biogenic, lightning, and biomass burning emissions, respectively. The separate contribution of the three sources to tropospheric ozone over Africa is shown in the supplement file. In both NH spring and NH autumn, the influence of biogenic emissions is mainly in the upper troposphere, while the effect of lightning* NO_x *peaks at lower levels. In NH spring, the contributions of the two sources in NH are comparable to that in SH. However, in NH autumn, the contributions of the two sources are mainly in the SH. Biogenic and lightning emissions are both the important sources for African tropospheric ozone. We have revised our discussion to make it more in-depth.*

10: Section 4.2 It seems that Figure 8 and Figure 9 are already sufficient for the discussion. I suggest to remove Figure 10 to make the paper more concise.

Thanks for the points. Fig. 10 in the last version not only supports the discussion for Figs. 8 and 9 in the last version but also provides additional information that is not available in these two figures. First, Fig. 10 shows the seasonal variation of the inflow and outflow flux of African ozone over Asia directly indirectly instead of separating the flux into ozone concentrations and winds. Second, the influence of the seasonal variation of the westerly jet is more clearly presented than Figs. 8 and 9. Third, the difference between the inflow and outflow flux is clearly shown, which is not available from other figures. In addition, the influence of the Somali jet on the lower tropospheric over western India in NH summer is captured by the inflow flux in the figure. For these reasons, we think it is better to keep Fig. 10 in this revision (now Fig. 12).