

**Reviewer #2:**

**Comment#2-1:** The manuscript represents a comprehensive modeling analysis of background ozone and its origins in China for a recent period of 2016 and 2017 and explains how differences in meteorology between the two years led to ozone differences. It uses a high resolution nested-grid version of the global chemical transport model (GEOS-Chem) and does a good job comparing to previously published coarser-resolution GEOS-Chem modeling studies of background ozone in China. The methodology used to quantify background ozone follows the conventional emission zeroing-out approach used by the literature. The manuscript is well-written and well organized. I recommend publication after the following comments are addressed.

**Response#2-1:** We thank the reviewer for the valuable comments. All of them have been implemented in the revised manuscript. Please see our itemized responses below.

**Comment#2-2:** Figure 3: I was surprised that lightning NO<sub>x</sub> has the largest contribution to background ozone in western China exceeding stratospheric ozone and that this contribution does not have a clear seasonality. I would expect lightning NO<sub>x</sub> to peak in summer; in fact, the figure shows it is lowest in summer (6.5 ppbv vs. 8-9 ppbv in other seasons). Is there a way to validate this result with observations or by comparing with literature values (if any). It will be helpful to put an uncertainty estimate to these numbers. From the model validation plots in Figure 2, I can see the model overestimates surface ozone in western China although there is just a couple of sites available. Could the overestimation be partly caused by an overestimation of ozone contributed by lightning NO<sub>x</sub>?

**Response#2-2:** Thanks for pointing it out. The magnitude and spatial patterns of lightning ozone enhancements in our simulation are generally comparable with Murray et al. (2016), although they did not provide seasonal values. We find although higher lightning NO<sub>x</sub> emissions in summer (Table 3 and Fig. S5), the lightning influences on surface ozone are also affected by elevation and vertical transport. The following text has been added. We have also added the standard deviations for all source attributions in Figures 3 and 4 following the reviewer's suggestions.

We now state in the text: "Lightning NO<sub>x</sub> emissions increase bimonthly mean surface MDA8 ozone by 6.5-9.9 ppbv averaged over China, with the largest contributions (typically more than 12 ppbv) found over the Tibetan Plateau (Fig. 4b). The large lightning ozone enhancements over the western China (annual mean > 7 ppbv) were also simulated by Murray et al. (2016), and these values were higher than those over the western US (annual mean of 3-5 ppbv). However, the model may overestimate springtime lightning ozone enhancements over the Tibetan Plateau as the model shows high surface ozone biases of more than 15 ppbv in spring over this region (Fig.2)." and "Although lightning NO<sub>x</sub> emissions are larger in July-August, the shorter ozone lifetime and stronger upward transport over central eastern China in these months can suppress downward mixing of lightning ozone enhancements to the surface (Fig. S4), resulting in their minimum influences there in the period. This also partly explains the decreases of surface ozone from spring to summer in the western China as shown in Fig. 2."

**Reference in the text:**

Murray, L.: Lightning NO<sub>x</sub> and Impacts on Air Quality, Current Pollution Reports, 2, 115–133, <https://doi.org/10.1007/s40726-016-0031-7>, 2016.

**Comment#2-3:** Pg 10, line 292-295: This statement needs to be elaborated; otherwise it sounds superficial. What are the possible interactions between domestic and foreign anthropogenic emissions and to what direction would these interactions affect ozone (i.e. increase or decrease)?

**Response#2-3:** Thanks for pointing it out. We now rewrite the statement: “The foreign anthropogenic contributions we estimate here (~5 ppbv for all seasons averaged over China), however, may underestimate their true contribution, since they are derived in the absence of Chinese domestic anthropogenic emissions and thus do not consider possible interactions with domestic emissions, e.g., ozone produced by foreign precursor enhancements reacted with domestic anthropogenic emissions.”

**Comment#2-4:** Pg 13, line 380-385: The statement that “the missing rest can be largely explained by contributions from global methane” is too assertive. Other factors such as the interactions between different sources may also play a role which will not be captured by the sensitivity simulations by zeroing off individual emissions.

**Response#2-4:** We now state in the text: “The missing rest can be largely attributed by contributions from global methane.” and “The discrepancies may be also due to non-linear interactional effects between different sources that are not captured by the sensitivity simulations with individual emissions turned off.”