The manuscript presents a modeling analysis to quantify the contribution of isoprene emissions under heat wave conditions in North China Plain on high ozone periods in summer 2017. It reaches two important conclusions that have not been considered in previous modeling analysis of ozone pollution during heatwaves in China: first isoprene emissions not only respond to high temperatures but also to water stress often associated with heat waves; second the recent increase in broadleaf trees and urban green spaces in China has led to increases in baseline isoprene emissions making the first point more important under heat waves. The analysis is solid and writing is clear in most parts. I recommend publication after my following comments are addressed.

RE: We thank the reviewer for the comprehensive comments to help to improve the manuscript. Please see the detailed responses to your comments below.

Main comments: My main concern is the modeling sensitivity analysis was conducted only for summer 2017 but the first part of the manuscript focuses on the difference of summer 2017 from the preceding years (2014-2016). While the sensitivity tests on isoprene emissions lead to better ozone simulation during high-ozone episodes in summer 2017, it is not clear how the same model settings affect ozone under more 'normal' conditions. This is important to know as it can show readers whether the changes in isoprene emissions in the model should be applied more broadly or only applied for certain conditions such as heatwaves. I suggest the authors pick a low ozone year and show how the same VPD and land type change schemes would affect ozone simulation in the model.

RE: We agree that it is important to do the sensitivity tests in particular over the normal year and high-ozone year. Therefore, besides the sensitivity in original manuscript, we conducted four sets of sensitivity studies for biogenic emissions over the summer of 2016, which is similar as what has been done for the summer of 2017 in the main manuscript. The specific cases include case 2 with biogenic emission using the land cover of 2003, and cases 3, 4 and 5 are the same as case 2 except for the inclusion of the VPD effect, both VPD and land cover of 2016, and VPD and land cover of 2016 combined with the effect of urban green spaces, respectively.

To address the reviewer's comments on how VPD and land cover changes affect ozone under normal year, we conducted another sets of simulations (the same as cases 2-4 discussed above) during June 8th to mid-July in 2016, similar period as 2017. The mean MDA8 ozone concentrations over NCP during this entire period in 2017 for case 2 is 79.03 ppbv, and statistical significant enhancement (1.34 ppbv) was achieved in case 3. In comparison to case 3, the land cover change in case 4 shows statistical significant increase as well (1.13 ppbv). As expected, looking at the entire period in 2016 (June 8–July 4), statistical significant, and even higher in relative to 2016, increase was achieved in case 3 (1.55 ppbv) compared to case 2 (90.11 ppbv), and case 4 (1.23 ppbv) compared to case 3. Therefore, the land cover and VPD may be applied in either episodic events or normal conditions. We have added the discussions from Line 405 to 414 in the revised manuscript.

Second, the VPD effect on isoprene emissions from Zhang and Wang (2016) was derived from one case study in the southeast US based on a modeling sensitivity analysis. It is not a process-level algorithm as MEGAN and whether the VPD scheme would work for the time period and spatial domain outside the study of Zhang and Wang (2016) has not been investigated. This should be stated in the manuscript. The authors may not be aware that a new water stress effect on isoprene emissions is now included in the newest MEGAN3; see Jiang et al. (2018). This literature should be referenced in the manuscript and discussed.

RE:

The uncertainty of Zhang and Wang (2016) has been addressed in the revised manuscript.

Regarding Jiang et al. (2018), we have illustrated the new approach and the potential impact on ozone formation in the revised manuscript, which has been shown below as well.

In the latest version MEGAN 3 (Jiang et al., 2018), a new approach was developed to quantify the drought effect on the isoprene emissions based on both photosynthesis and water stress, yielding a general reduction of monthly mean isoprene emission across the globe, including northern China. The impact of changes in isoprene emissions, based on the new method, on ozone formation deserves further evaluation in future.

Technical issues: Line 41: add ozone after MDA8.

RE: This has been corrected in the revised manuscript.

Figure 1: explain what H, B, and T in the figure stands for.

RE: They have been added in the revised manuscript.

Line 195: How was the interpolation done? Simply averaging over a 0.5x0.5degree grid? As this is a comparison of observations between different years, I do not understand why spatial interpolation is necessary. Is it because the site numbers differ by year?

RE:

The reviewer is correct and a simple averaging was used for the interpolation. The reason to interpolate was due to the differences in number of sites among different years.

Figure 3: how is the regression relationship calculated for each summer? For each day, do you average over all the sites over NCP, average over the 0.5x0.5 degree grid, or treat individual sites as separate data points? Will the slope and correlation slope change with those different representations of data?

RE: The meteorological observations from CMA and ozone observations from China National Environmental Monitoring Centre were used to calculate their regression relationship. However, the sites numbers and locations between meteorological and ozone observations were different. Therefore, to pair up the air quality and meteorological stations, for each air quality station, the closest meteorological station was selected. After that, daily meteorology and ozone data were averaged regionally over the NCP.

The meteorological sites were uniform distribution in general, whereas most air quality sites were located in urban area (shown in Fig.1). In this case, if there is no pairing up, in another word, direct regional mean was operated on meteorology and ozone observations separately, the comparison then loses the consistency. We also tested this method (Fig. R3), yielding much lower correlation coefficient. Thus, the pairing up method was used in the correlation analysis.

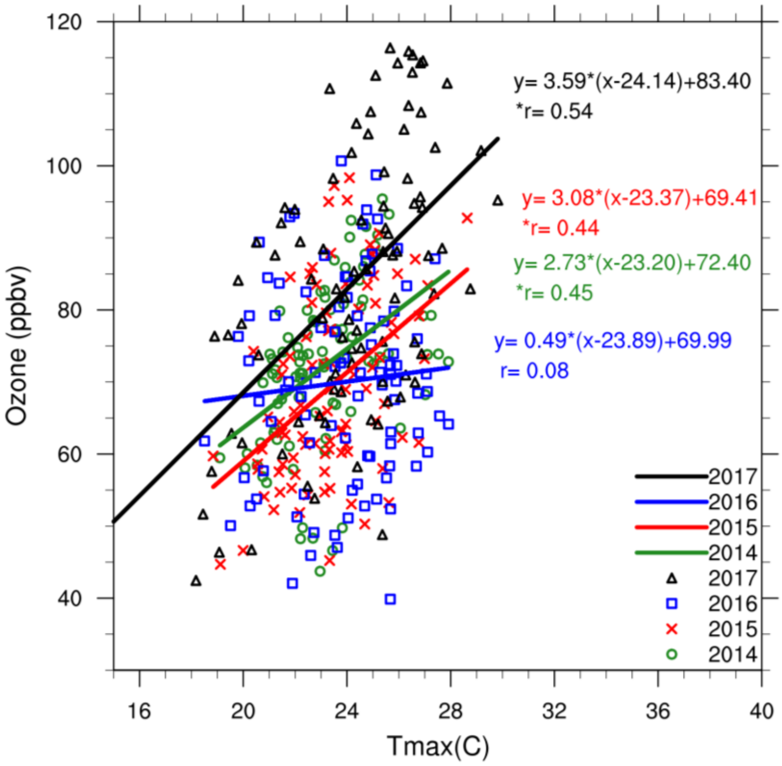

Fig. R3 The correlation between summer MDA8 ozone and daily maximum 2-meter temperature (Tmax) during 2014-2017 over NCP. Regional mean was calculated from the observational sites over NCP.

Line 228: Figure 4 shows all four years, not just 2017.

RE: This has been corrected in the revised manuscript.

Line 230-231: Did you verify these two periods were hit by heat waves? What definition of heat waves were used? Did the heat wave affect the whole NCP or some portion of it? It will make your argument stronger if there is also a spatial association that the sites affected by the heat waves had higher ozone concentrations than those sites not affected. I also suggest the authors describe the temperature in degrees for the two high-ozone periods in the text. July 6-14 2017 had higher temperature than the two periods you noted and ozone was also high. Why did you not highlight that period in the analysis?

RE: Right, during the two periods, the North China Plain was hit by heat waves.

The definitions we used in this study is: for each station, three or more continuous days with daily maximum 2-meter air temperature exceeding the 95th percentile of the summers during the past thirty-year (1987-2016). Since the meteorological measurement data mostly located near the airports (blue dots in Fig. 1 of the main manuscript), the distribution is relatively sparse and not all the stations were hit by the heat waves. For example, there is a total of 58 stations, and among these stations, 22 of them were hit by heat waves during June 14-21 and June 26-July 3.

Regarding the comments of ozone concentration comparison between the heat waves and non-heat wave periods, we first match the meteorological stations with observational ozone, and then composite the ozone concentrations during heat waves and non-heat waves. The mean MDA8 during heat waves and non-heat waves are 111.62 and 107.96 ppbv, indicating higher ozone concentrations during heat waves, further implying the impact of heat waves on ozone formation.

Since the reviewer suggest to add the descriptions of temperature in degrees, we now added in section 3.2 in the revised manuscript. During the first three days of these two high ozone episodic events, the regional mean daily maximum temperature is 32.3 °C, accounting for 90th percentile relative to a thirty-year period during 1987-2016. Moreover, almost half of the stations with at least three continuous days exceeding their respective 95th percentile from 1987-2016, satisfying the definitions of heat waves.

Although temperature during July 8 to 20 is relatively high, wind velocity during July 8th and 9th is too high to favor the ozone accumulation. In the following two days, the slow wind with high surface temperature provide appropriate photochemical reaction conditions which are conductive to ozone accumulation. The increased precipitation with reduced solar radiation (figure of radiation not shown) from July 14th make the high ozone events unlikely occur.

Figure 4: What is the gray dashed line in each panel?

RE: The blue dash lines in each panel represented 31 degree Celsius, and this has been explained in the revised manuscript.

Line 268-278: the land cover change is shown for a longer period (between 2003 and 2016), not over the study period (2014-2017). I think the authors meant to say that the use of an older land cover map can lead to underestimate of isoprene emissions and such an underestimate may be exaggerated in years with high temperatures and high VPD. I suggest the authors make this point explicitly in the text.

RE: This has been clearly addressed in the revised manuscript, which is shown below as well.

Combining the point *a)* described above, the underestimation of biogenic emission due to changes in land cover may be exaggerated in years with high temperatures and high VPD.

Reference：

Jiang, X. Y., Guenther, A., Potosnak, M., Geron, C., Seco, R., Karl, T., Kim, S., Gu, L. H., and Pallardy, S.: Isoprene emission response to drought and the impact on global atmospheric chemistry (vol 183, pg 69, 2018), Atmos Environ, 185, 272-273, 2018.

Zhang, Y. Z., and Wang, Y. H.: Climate-driven ground-level ozone extreme in the fall over the Southeast United States, Proc Natl Acad Sci USA, 113, 10025-10030, 10.1073/pnas.1602563113, 2016.