Dear Referees,

Thanks for giving us an opportunity to revise our manuscript (acp-2019-1045). We appreciate your positive and constructive comments. We have studied these comments carefully and make revisions on the manuscript. These comments and the corresponding replies are listed below.

The referee's comments are highlighted by gray, and followed by the comments are our responses. The symbol "≫" is the original texts in the manuscript. The modified sentences are marked by underlines. The added/replaced texts are colored by red.

With regards,

Shuqi Yan, Bin Zhu*, and all co-authors.

Replies to Referee#1

1. Line 37-38: As indicated in IPCC AR5, “aerosol-cloud-radiation interactions” is suggested to be rephrased as “aerosol-radiation interaction” and “aerosol-cloud interaction” separately.

≫Line 37-38: ...which are called as aerosol-cloud-radiation interactions...

Thank you for this valuable suggestion. We have rephrased it to be "...which are called as aerosol-radiation and aerosol-cloud interactions..."(Line 38-39).

2. Line 41: “Many”->”Previous”

≫Line 41: Many studies have analysed...

Thank you for this valuable suggestion. We have changed all the "many studies" to "previous studies" (Line 35, 42, 219).

3. Line 45: “lower supersaturation” ??

≫Line 45: As a result, urban areas commonly experience higher temperatures and lower vapour contents. These conditions induce a lower supersaturation that is unfavourable for fog formation.

Thank you for this valuable suggestion. We change this sentence to "…These conditions induce a lower relative humidity supersaturation that is unfavourable for fog formation" (Line 47).

4. Lines 64-65: Some important references are missing regarding the observational evidences of aerosol boomerang effect in China, e.g., Wang et al., AE 2015, doi: 10.1016/j.atmosenv.2015.04.063; Guo et al., GRL 2017, doi: 10.1002/2017GL073533; Liu et al., Sci. Rep. 2019, doi:10.1038/s41598-019-44284-2.

≫Lines 64-65: However, if aerosol concentration exceeds a certain threshold, this promoting effect disappears (Quan et al., 2011) or even turns into a suppressing effect due to the strong vapour competition (Koren et al., 2008; Rangognio, 2009).

Thank you for this valuable suggestion. We have added these references to the end of this sentence. Line 69: .....or even turns into a suppressing effect due to the strong vapour competition (Guo et al., 2017; Koren et al., 2008; Liu et al., 2019; Rangognio, 2009; Wang et al., 2015).

5. Lines 69-71: I notice that the work by Yan et al. JGR (2019) mentioned here is also from the same research group. Also, it occurs to me that the motivation seems a little confused: Since previous work has "quantitatively" proved…, why the authors attempt again to "quantitatively" confirm by model simulation of a fog event. Two "quantitatively " is redundant. Therefore, this sentence is suggested to be rephrased as follows: e.g. Our recent observational work (Yan et al., 2019) indicated a decreasing trend in fog days, and …"

≫Lines 69-71: Yan et al. (2019) analysed decadal trends of fog days and quantitatively proved that the inhibiting effects of urbanization outweigh the promoting effects of aerosols on fog during the mature urbanization stage. Their study inspires us to quantitatively confirm the roles of urbanization and aerosols.....

Thank you for this valuable suggestion. The redundant "quantitatively" is deleted. We have changed this sentence to "Our recent observational work (Yan et al., 2019) indicated a decreasing trend in fog days, and the inhibiting effects of urbanization outweigh the promoting effects of aerosols on fog during the mature urbanization stage. This study aims to quantitatively confirm the roles of urbanization and aerosols....."(Line 73-76).

6. Line 75: "facilitates"-> "is expected to facilitate"

≫Line 75: This work facilitates the understanding of.....

Thank you for this valuable suggestion. We have changed the following sentences: 1) Line 80: "This work is expected to facilitate the understanding of..."; 2) Line 306: "This study is expected to facilitate a better understanding of...".

7. Line 85: Something is suggested to be mentioned concerning Section 4 immediately after “Section 3.6 discusses the rationality and reliability of the results.”

≫Line 85: Section 3.6 discusses the rationality and reliability of the results.

Thank you for this valuable suggestion. We have added "Section 4 concludes the findings of this study" to the end of this sentence (Line 90-91).

8. Line 90: it is suggested to clarify which city you are referring to? Since the reader cannot easily get any info from either text or Figure 1b.

≫Line 90: SX is ... approximately 30 km away from the nearest large city (Fig. 1b).

Thank you for this valuable suggestion. We have changed this sentence to "SX is ... approximately 30 km away from the nearest large city, Huainan (Fig. 1b)" (Line 96). The city of Huainan is also marked in Figure 1b.

9. Line 97: “replace”-> “used to replace”

≫Line 97: The data are resampled from 500 m to 30 arc-seconds (approximately 1 km) and replace the geological data of the WRF model.

Thank you for this valuable suggestion. We change this sentence to "The data are resampled from 500 m to 30 arc-seconds (approximately 1 km) and used to replace the geological data of the WRF model" (Line 103).

10. Lines 160-165: The logic seems a little problematic: since the fog holes are mainly caused by urbanization, as demonstrated in the references in this paragraph (aerosol effect is not mentioned and is supposed to not be the focus here), why you mentioned the effect of aerosol pollution. It is generally thought that urbanization effect tends to reduce LWP whereas aerosol tends to accumulate the formation of fog. The combined effect is highly dependent on the competing effect of the two factors. Here it is not accurate to argue that both of them “reducing the LWP or advancing the dissipation of fog”.

≫Line 160-165: …… We assume that urbanization and air pollution could have profound effects on fog by reducing the LWP or advancing the dissipation of fog.

Thank you for this valuable suggestion. We agree that fog holes are mainly caused by urbanization, not by aerosols. We aimed to express that "the combined effects of urbanization and aerosols lead to fog holes", not "both of them lead to fog holes". To avoid the problem you mentioned, we change the last sentence to "We assume that urbanization could have profound effects on fog by reducing the LWP or advancing the dissipation of fog, and the role of aerosols on fog is weaker than that of urbanization" (Line 170-171).

11. Section 3.2: What are the criteria for you to determine a fog event from model-simuated LWP, which is required to be clarified here.

Thank you for this valuable suggestion. The criteria for fog is LWP>2 g/m^2 (Jia et al., 2018). We clarify it in Section 3.2: "Satellite cloud image and modelled LWP (>2 g/m^2) can represent the observed and simulated fog zone" (Line 173).

References:

Jia, X., Quan, J., Zheng, Z., Liu, X., Liu, Q., He, H., and Liu, Y.: Impacts of anthropogenic aerosols on fog in North China Plain, J. Geophys. Res.-Atmos., 124, 252–265, https://doi.org/10.1029/2018jd029437, 2018.

12. Section 3.3: The authors attempted to discuss the complicated non-monotonic effect of aerosol on fog formation by differing the emission rate, which is not very common. Why not used the aerosol concentration or CCN or Na that can well represent the real atmospheric pollution level for the time period investigated here? I am curious of the actual CCN or Na concentration for the experiment of u0e3?

Thank you for this valuable suggestion. We agree that CCN can better represent the air pollution level. The $CCN_{0.1}$ concentration of each experiment is marked in the new Figure 8 (Line 510-514), because the supersaturation in fog is commonly less than 0.1% (Mazoyer et al., 2016). The $CCN_{0.1}$ of current pollution level (u0e3) is 570 cm^{-3}.

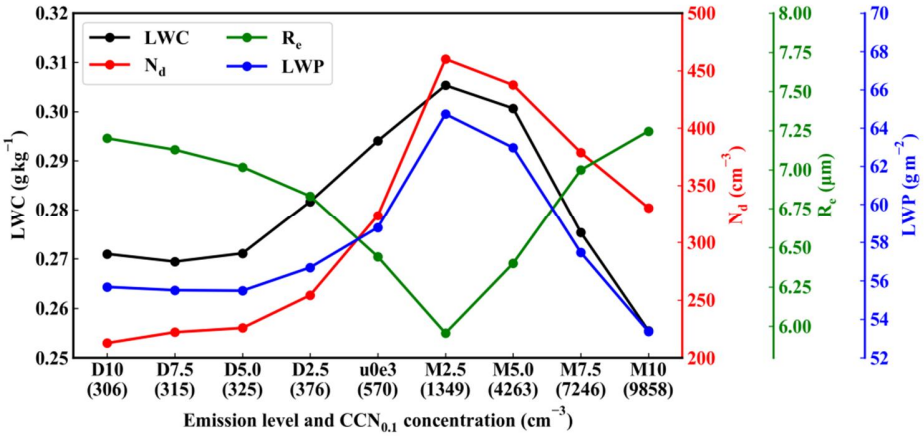

Figure 8. Relationships of the microphysical parameters (LWC, N_d, R_e and LWP) with emission level and $CCN_{0.1}$ concentrations. These parameters are the time-height averages (time average for the LWP) in fog.

References:

Mazoyer, M. , Burnet, F. , Roberts, G. C. , Haeffelin, M. , & Elias, T. (2016). Experimental study of the aerosol impact on fog microphysics. Atmospheric Chemistry and Physics, 1-35.

13. Lines 215-216: It will be misleading for the statement "the current pollution level in China is still located in the promoting regime rather than the suppressing regime of fog occurrence". Both ideal simulation (e.g., Rosenfeld et al. Science, 2008) or observational studies (Wang et al., AE 2015; Guo et al., GRL 2017) indicated that the tipping point tends to occur at AOD of 0.3-0.4 or CCN concentration of 1200/cm3. Recent observational work by Ilan Koren et al. (Science, 2014) suggested the cloud and precipitation is most sensitive to aerosol over the South Ocean. By comparison, the average AOD from MODIS in East China is on average much larger than 0.6, irrespective of the meteorological conditions.

≫Lines 215-216: The aerosol concentration of the transition point (experiment M2.5) is higher than that of u0e3 (Fig. 8), revealing that the current pollution level in China is still located in the promoting regime rather than the suppressing regime of fog occurrence.

Thank you for this valuable suggestion. The $CCN_{0.4}$ of u0e3 is 6023 cm^{-3}, higher than $CCN_{0.4}$=1200 cm^{-3} that revealed by Rosenfeld et al. (Science, 2008). We agree that the AOD value of East China is larger than 0.6. It seems that the current pollution level could suppress fog rather than promotes fog.

The studies you listed mostly aim at convective clouds. Aerosols affect convective clouds through two competing mechanisms: 1) invigorating convection by promoting vapor condensation. 2) suppressing convection by blocking solar radiation and reducing surface heat flux. Under polluted conditions

(AOD>0.3 or $CCN_{0.4}$>1200 cm^{-3}), the suppressing effect outweighs the invigoration effect, so the turning point occurs (Koren et al. Science, 2008; Rosenfeld et al., Science, 2008). This suppressing effect does not exist in fog because fog commonly formed at night. Therefore, the turning point in fog might occur later than that in convective clouds. In North China Plain where air pollution is thought to be more serious, a case study by WRF-Chem also indicates that fog properties (e.g., LWC, N_d and LWP) increase monotonically when emission intensity varies from 0.05-fold to 1-fold. It is consistent with our statement "the current pollution level in China is still located in the promoting regime rather than the suppressing regime of fog occurrence".

The above discussions have been included at the end of Section 3.4 (Line 224-232). Additionally, the statements are given by a more cautious manner: (Line 221-223): …possibly indicating that the current pollution level …; (Line 26, Abstract): the current pollution level in China could be still below the critical aerosol concentration that suppresses fog.

14. Lines 205-206: times is redundant and should be removed.

≫Lines 205-206: For example, the name M2.5 means multiplying by 2.5 times; the name D10 means dividing by 10 times.

Thank you for this valuable suggestion. We change this sentence to "For example, the name M2.5 means multiplying by 2.5; the name D10 means dividing by 10" (Line 211).

15. Line 448: it is better to indicate the year of 2017 following 03 January in the figure caption.

≫Line 448: Figure 2. The performance of the simulated fog zone at 08:00 03 January.

Thank you for this valuable suggestion. We change the caption to "The performance of the simulated fog zone at 08:00 03 January 2017" (Line 476).

16. Figure 3: it is suggested to show the major cities in the regions of interest shown in panel a and b, given the convenience to better understand the fog hole induced by urban. Besides, two subregions in Figure 3 is better to be marked in Figure 1 or 2.

Thank you for this valuable suggestion. The subregions of interest are marked in the new Figure 2 (Line 475-480). The cities with fog holes are marked in the new Figure 3 (Line 482-487).

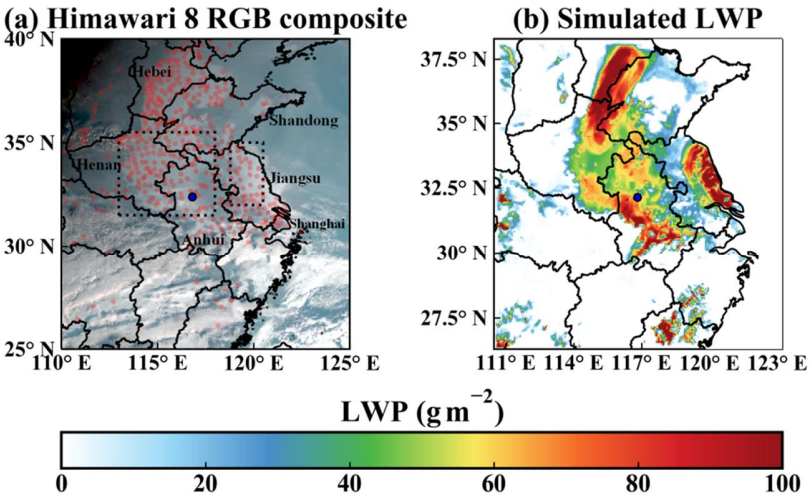

Figure 2. The performance of the simulated fog zone at 08:00 03 January 2017. (a) Himawari 8 RGB composite cloud image overlaid with the MICAPS observation sites (light red dots) at which fog was observed (relative humidity > 90 % and VIS < 1 km). (b) Simulated LWP distribution. Only LWC below 1500 m are integrated. The blue dots are the SX site. The two dashed rectangles in (a) are the subregions of interest in Fig. 3.

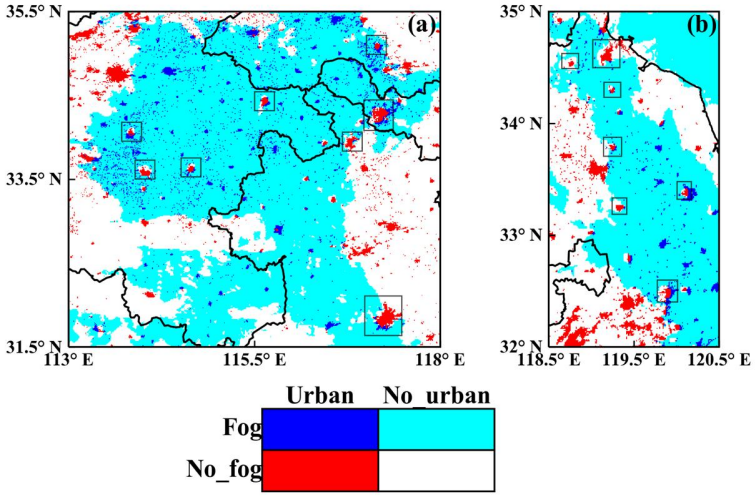

Figure 3. Two sub-regions (a and b) with obvious fog holes on the Himawari 8 image at 11:00 03 January. The fog zone, which is represented by albedo > 0.45 (at 0.64 μm) and brightness temperature > 266 K (at 12.4 μm) (Di Vittorio et al., 2002), is marked with cold colours (blue or cyan). The urban areas are marked with blue or red. The red and white pixels surrounded or semi-surrounded by cold colours are fog holes, and among these pixels, the red pixels indicate the fog holes over urban areas. Some of the urbans with fog holes are marked by rectangles.